The Engineer

LONDON, FRIDAY, SEPTEMBER 18, 1942.

PUBLIC NOTICES

COUNTY COUNCIL OF THE COUNTY OF LANARK

EDUCATION COMMITTEE

THE TECHNICAL COLLEGE, COATBRIDGE

The Education Committee INVITE APPLICATIONS for the POST of PRINCIPAL TEACHER of ENGINEERING (Mechanical and Electrical) in the Technical College, Coatbridge.

The courses prepare students for Ordinary and Higher National Certificates, and the duties involve both day and evening work. The salary payable will be at the rate of £420 per annum, together with a responsibility payment of £100 per annum, making a total salary of £520 per annum.

In addition, a war bonus, which is at present at the rate of 5 per cent. per annum, will be paid. The normal hours of employment will be 30 per week, including preparation, and payment at Continuation Class rates will be made for teaching hours in excess of that number.

The post will be confined to applicants holding a University Degree in Engineering, and preference will be given to candidates who have had suitable practical and teaching experience.

Applications must be lodged not later than FRIDAY, 2nd OCTOBER, 1942, with the undersigned, from whom forms of application may be obtained.

Canvassing of members of the Education Committee, either directly or indirectly, will be a disqualification.

R. C. T. MAIR,
Director of Education and
Depute County Clerk.

Lanarkshire House,
191, Ingram Street,
Glasgow, C.1. 8783

SITUATIONS OPEN

COPIES OF TESTIMONIALS, NOT ORIGINALS, UNLESS SPECIFICALLY REQUESTED.

TO ADVERTISERS UNDER BOX NUMBERS IN SITUATIONS OPEN SECTION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge, and co-operation is asked for.

IMPORTANT

Advertisers in Situations Open Column should make themselves acquainted with the terms of

STATUTORY RULES & ORDERS 1941 No. 2069

RESTRICTION ON ENGAGEMENT ORDER

WANTED, MAN with Technical Knowledge to REPRESENT well-known firm of London stockholders for sale of valves to laundry and general engineers and all steam users. State salary required.—Address, 8780, The Engineer Office. 8780 A

AUTHORS REQUIRED to WRITE TEXT-BOOKS on Mathematics, Mechanics, Physics and all branches of Engineering Technology. Straight fee—no royalties.—Write in strict confidence, stating qualifications and subjects.—Address, 8779, The Engineer Office. 8779 A

OVERSEAS EMPLOYMENT. — ENGINEERING FITTERS, under 45 years of age, are REQUIRED for the Gold Coast. Candidates must be in first-class physical condition, have served five years' apprenticeship with firm of good standing, and have been employed in the capacity of Fitter or other engineering work since completing apprenticeship. Monthly salary £45, plus £5 war bonus. Free passages out and home on half-pay. Free housing, light, hospital, and medical attendance. Life, accident, and baggage insurance effected by employers.—Written applications (no interviews), giving details of age, apprenticeship, experience, and name of present employers, should be sent to the SECRETARY, Overseas Manpower Committee (Ref. 310B), Ministry of Labour and National Service, Hanway House, Red Lion Square, London, W.C.1. 8784 A

THE Post You are Seeking May Not be Advertised in this Column, but do not lose the Opportunity of Bringing your Requirements before all those who would be interested and could employ you. An Advertisement in the "Situations Wanted" Column would be seen by all Leading Engineering Concerns for the cost of Four Lines, 6s.; 1s. 6d. for each Additional Line. There is no better way of covering so large a field for such a small charge.

The Engineer

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NOTICE

CORRESPONDENCE *re* Accounts and Remittances should be sent in future to:

28, ESSEX STREET, STRAND, LONDON, W.C.2, and NOT to Bath.

This change has been caused by enemy action, and co-operation is earnestly asked for.

SITUATIONS OPEN

WANTED, COMMERCIAL MANAGER with technical qualifications and technical experience for Buying and Selling New and Second-hand Electrical Plant, comprising Turbo-alternators, Electric Motors, Switchgear, Power Station Equipment, &c. Please furnish full particulars of age, experience and salary required.—Address, 8782, The Engineer Office. 8782 A

CREATIVE ENGINEER DESIGNER REQUIRED by company near London. Applicant must have first-hand knowledge of Static and Dynamic Balancing at Low and High Speeds; also experience in Solving Suspension, Transmission, and Vibration Problems. Accustomed to meeting executives and technical personnel on questions of intricate design involving application of new principles. Permanent position of exceptional interest for first-class man.—Reply in first instance to "ENGINEER," c/o Sturges and Co., 58, Victoria Street, S.W.1. 8777 A

SITUATIONS WANTED

CHARTERED ACCOUNTANT, Presently Employed by large public company, has been scheduled for transfer to more vital war industry by Ministry of Labour. Seven years' commercial experience, includes amalgamation negotiations, full control of secretarial and accounting organisation of holding and subsidiary companies, together with management control; age 33; minimum salary, £1200 p.a.—Box 543, Robertson and Scott, Edinburgh, 2. 8781 B

CHIEF ENGINEER of Large Factory SEEKS a SIMILAR POSITION in a rural district; fully qualified as a designer and administrator. Present salary four figures.—Address, P4370, The Engineer Office. P4370 B

WORKS ENGINEER, at Present in Midlands, REQUIRES APPOINTMENT in London area; factory extensions, plant maintenance and erection; internal services, &c.—Address, P4369, The Engineer Office. P4369 B

SITUATIONS WANTED

CIVIL ENGINEER, B.Sc., 1st Class Hons., A.M. Inst. C.E., age 35, fifteen years' experience design and construction of civil and structural engineering projects and industrial and factory construction work, at present chief engineer of office of civil engineers and contractors, SHORTLY AVAILABLE for POSITION of NATIONAL IMPORTANCE.—Address, P4364, The Engineer Office. P4364 B

CHIEF ENGINEER (43). Controlling Large concern, DESIRES CHANGE; exceptionally wide experience in mech., elec., civil and chemical engineering, also research, development, and sales organisation.
Release arranged end of September.
Address, 4368, The Engineer Office. P4368 B

ENGINEER, with Many Years' Practical Experience, machine tools, works equipment, precision work; able to conceive and develop new ideas; travelled; thorough knowledge French, if desired, can organise French-speaking special technical staff for present and post-war possibilities, WISHES a POST of National Importance. Would consider works management or technical assistant to managing director.—Address, P4341, The Engineer Office. P4341 B

IF the Man You Are Seeking is Not Amongst those Advertising in this Column, a Small Announcement in the "Situations Open" Column will Quickly and Economically Produce the Right Selection of Applicants, at the same time Eliminating Waste of Effort, Waste of Time, and Waste of Opportunity. The charge is Four Lines or under, 6s.; each Additional Line, 1s. 6d. Box Numbers, 1s. extra, which includes despatch of all replies.

MECHANICAL ENGINEER (34), B.Sc., A.M.I.M.E., A.M.I.C.E., nine yrs.' experience designing tanks and armoured fighting vehicles, four yrs. lecturing, DESIRES POST of NATIONAL IMPORTANCE. Salary £750.—Address, P4362, The Engineer Office. P4362 B

PETROLEUM ENGINEER (Age 55) DESIRES SITUATION; has held chief engineer's post for fifteen years and has administrative experience in refinery overseas. Good references.—Address, P4361, The Engineer Office. P4361 B

PURCHASING ENGINEER (40) DESIRES CHANGE; general engineering experience in workshops, drawing-office, management, and sales.—Address, P4371, The Engineer Office. P4371 B

RESEARCH.—Fully-qualified MECHANICAL ENGINEER, specialising in design, construction, and operation of research instruments, apparatus, DESIRES POST in London.—Address, P4367, The Engineer Office. P4367 B

CHIEF DRAUGHTSMAN, Widely Experienced engineering design, large and medium industrial installations, civil, structural, mechanical, efficient staff controller, DESIRES CHANGE to important war work; minimum, £700.—Address, P4366, The Engineer Office. P4366 B

DESIGNING DRAUGHTSMAN (21) REQUIRES POSITION in firm with small drawing-office under Essential Works Order; six years' experience in small mechanisms and general structural work; salary £286.—Address, P4372, The Engineer Office. P4372 B

YOUNG DRAUGHTSMAN REQUIRES POSITION with firm of Mechanical Engineers in London region; would prefer diesel firm or similar.—Address, 8785, The Engineer Office. 8785 B

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CLASSIFIED ADVERTISEMENTS CLOSE FOR PRESS-NOON WEDNESDAYS

The Engineer

Annual Subscription Rates

(including postal charges)

BRITISH ISLES	... ...	£3	5 0
CANADA	... ...	£2	18 6
ABROAD	... ...	£3	3 0

(except Canada)

ADVERTISEMENTS

The Charges for Classified Advertisements are 1/6 per line up to one inch—minimum charge, 6/-; those occupying one inch or more at the rate of 18/- per inch. Box numbers, 1/- extra, except in the case of advertisements under "Situations Wanted." Orders MUST be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Wednesday afternoon.

Letters relating to the Advertisement and the Publishing Departments of the Paper are to be addressed to the Publisher; all other letters are to be addressed to the Editor of THE ENGINEER.

Postal Address,
28, Essex Street, Strand, London, W.C.2.

Teleg. Address,
"Engineer Newspaper, Estrand, London."
Tel., Central 6565 (10 lines).

AGENCIES

AGENT REQUIRED for the Sale of Protective Industrial Garments to factories.—Address, P4363, The Engineer Office. P4363 D

MACHINERY, &c., WANTED

WANTED, PLATE SHEARS, 4ft. 6in. minimum length of bottom plate; 6ft. 6in. max. length of blade; min. lift of apron 6in.; cap. 1¼in. thick mild steel.—Address particulars to 8786, The Engineer Office. 8786 F

WANTED, 6in. PIPE-BENDING MACHINE, preferably motor driven. Full particulars.—Address, 8769, The Engineer Office. 8769 F

WANTED, TWO Electric or Petrol-driven Lister AUTO. TRUCKS or other good make.—Address, 8775, The Engineer Office. 8775 F

ALFRED HERBERT, Ltd., Coventry, PAY BEST PRICES FOR SECOND-HAND MACHINE TOOLS in good condition by first-class makers.
Write, wire, or 'phone, and our representative will call.
'Phone: 88781 (12 lines), Coventry; Telegrams: "Lathe, Coventry." 1002 F

We are licensed by the Machine Tool Control for the purchase of all classes of Machine Tools, and we offer good prices for surplus Machinery in any quantities, large or small.

F. J. EDWARDS, LTD.
359, EUSTON ROAD, LONDON, N.W.1
Telephone No.: EUSton 4681
Telegrams: "Bescotools, Norwest, London."

For continuation of Small Advertisements see page 54.

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all geared, hardened and ground throughout, ball and roller bearings, swivelling head, 30"x8" Table
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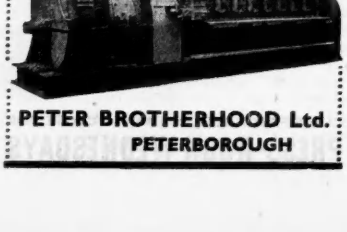
DIESEL **ENGINES**



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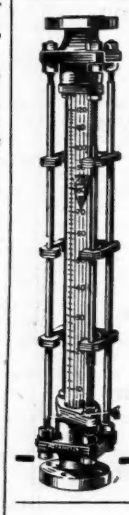

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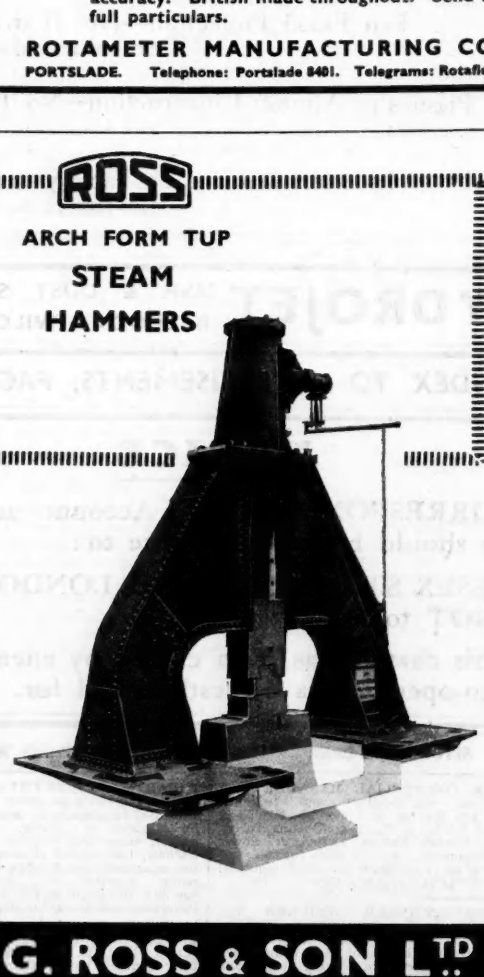


R. G. ROSS & SON LTD
EGLINTON ENGINE WORKS,
Telegrams: "Glenros, Glasgow" **GLASGOW C. 5.** Telephone: South 2283 (3 lines)
LONDON OFFICE: 52, GROSVENOR GARDENS, S.W.1.

BRAITHWAITE
PRESSED STEEL TANK
BRAITHWAITE & CO. ENGINEERS, L
London Office *Temporary Address:*
22, KINGS HOUSE, HAYMARKET, S.W.
Telephone: WHI 3993. Telegrams: Brombito-Pa

FIELDING & PLATT LTD.
GLOUCESTER
See our displayed Advertisement
SEPT. 11

THE standardised card advertisements below are inserted in place of the firms' large advertisements which have been omitted due to the paper shortage

BROWNLIE & MURRAY Ltd.
Possil Ironworks, Possil Park, Glasgow
See our displayed advertisement
AUGUST 21

BUTTERS BROS. & CO. LTD.
LONDON - GLASGOW - BIRMINGHAM
See our displayed advertisement
AUGUST 21

CLAYTON, SON & CO. LTD.
MOOR END, HUNSLET, LEEDS
See our displayed advertisement
AUGUST 28

COWANS SHELDON & CO. Ltd.
CARLISLE, ENGLAND
See our displayed advertisement
AUGUST 21

DAVY and UNITED ENGINEERING CO. LTD.
PARK IRON WORKS, SHEFFIELD
See our displayed advertisement
SEPTEMBER 4

THE STEEL COMPANY OF SCOTLAND
37, Renfield Street, Glasgow, C.2
See our displayed advertisement
SEPTEMBER 4

TAYLOR & HUBBARD LTD.
KENT STREET, LEICESTER
See our displayed advertisement
SEPTEMBER 4

TRIER BROTHERS LTD.
34, VICTORIA ST., LONDON, S.W.1
See our displayed advertisement
AUGUST 21

WINGET LIMITED
ROCHESTER, KENT
See our displayed advertisement
SEPTEMBER 4

THE G. H. GASCOIGNE CO. LTD.
Gascoigne House, Berkeley Avenue, Reading
KE-KLAMPS
FOR TUBULAR CONSTRUCTION
See our displayed advertisement August 21

A Seven-Day Journal

Tube Shelters

EIGHT new tube shelters in the London area, it was announced last week, are now so nearly completed that in emergency they could be brought into use without delay. Actually it is not intended to throw them open for the use of tube shelterers unless and until there is a need for the extra accommodation they will provide. These shelters, the design of all of which is practically the same, have been constructed in such positions that they can become parts of new tube railways that may be driven below London when the war is over. Each shelter consists of two tunnels side by side, each 16½ft. diameter. These tunnels were driven by methods similar to those usually employed for boring such tunnels in the London area. But it is interesting to note that the place of the more usual cast iron lining has been taken to a considerable extent by pre-cast concrete blocks. The use of this alternative material was referred to by Mr. Halcrow, in his Thomas Hawksley Lecture before the Institution of Mechanical Engineers last November. For their special use as shelters, the tunnels are divided by a concrete slab forming upper and lower "floors." Each shelter is about 1200ft. long and capable of holding 2000 people. Cross-passages provide space for medical aid posts, control rooms and the like. The tunnels lie at levels between 75ft. and 110ft. below ground level and to each there are several alternative entrances. Four of the shelters are north and four south of the Thames. The Exchequer is paying for the cost of the construction of these shelters and for their maintenance.

Control of Paper

THE provisions of the new Control of Paper Order, which came into force on Monday, September 7th, are in the main of little interest to engineers. Only that quantity of paper which is reasonably required may now be used for any document, leaflet, pamphlet, report, letter, or memorandum, whether printed, written, or typewritten. Additions are made to a number of paper articles prohibited or restricted, but few of these are of interest to engineers except in their private capacities. The use of paper for advertising, for circulars, wrappings, packing, and labels is restricted, and further restrictions are placed on posters. Advertising circulars relating to the sale of goods or to any business may in general be distributed only on pre-payment of at least 1d. for each circular. Existing prohibitions are maintained, including the ban on new newspapers, magazines, and other periodicals, whilst a new provision limits the advertising space in such publications, and gives legal form to restrictions already largely in use.

Government Appointments

IT was announced last Monday, September 14th, by the Ministry of Supply that Sir W. Charles Wright, the Controller of Iron and Steel, has resigned for medical reasons. Sir W. Charles Wright was, until he took up that appointment in 1940, chairman of Baldwins, Ltd., and Guest Keen Baldwins Iron and Steel Company, Ltd. His age is sixty-six. It is interesting to note that he held a corresponding position as Controller of Iron and Steel Production in the Ministry of Munitions of War during the previous war from 1917 to 1919. He was President of the Iron and Steel Institute, 1931–33, and President of the British Iron and Steel Federation, 1937–38. He was created C.B. in 1918 and K.B.E. in 1920. His place in the Ministry is to be taken by Sir John Duncanson, the Deputy Controller. Sir John began his connection with the Ministry as Director of Heavy Steels, Shell Steel, and Semi-Finished Steel, and became Deputy Controller in Charge of Iron and Steel Supplies in September, 1940. He originated the iron and steel supplies distribution scheme. ... On the same day the Ministry of Aircraft Production and the Air Ministry jointly announced that Sir Robert Renwick has been selected for the newly created appointment of Controller of Communications Equipment in the Ministry of Aircraft Production. He will become a member of the Aircraft Supply Council and will be assisted by Sir Robert Watson-Watt as Vice-Controller. Sir Robert Renwick has also been appointed Controller of Communications in the Air Ministry, in which Sir Robert Watson-Watt is Scientific Adviser on Telecommunications. These arrangements, it is considered, will ensure still closer co-ordination between the two Departments. It will be recalled that Sir Robert Watson-Watt was responsible for the initial experiments in radiolocation, and that Sir Robert Renwick was appointed Chairman of the Radiolocation Committee about a year ago.

Anglo-U.S. War Materials Production

DURING the past week the U.S. Office of War Information issued a statement dealing with available supplies of fibre for the making of ropes and similar products. The Japanese occupation of the Philippines and the Netherlands East Indies cut off the chief source of Manila fibre and interrupted supplies from one of the major sources of sisal. Fortunately, quite large stocks of fibre were held both by Britain and America when the Japanese came into the war, and they are expected to be great enough if distributed with care to tide over the period until new sources can come into production. Several hundred acres each week are now being cleared of jungle in Panama and Costa Rica and sown for the growing of fibre crops. Arrangements are being made for the import into America of sisal grown in Tanganyika, Kenya, and Uganda to replace the lost East Indies supplies. In Panama and Costa Rica 20,000 acres are being planted with abaca, from which Manila fibre is obtained. It will come into production in 1943, and planting can be greatly extended if the project proves successful. The acreage under sisal in Haiti is to be doubled, and henequen fibre, which though not good for rope is suitable for binder twines, is being obtained from Mexico. In the nineteenth century hemp was much used for rope-making, and now hundreds of thousands of acres in America are being planted with hemp.

Essential Work in the Coal Mines

IT was announced last Saturday, September 12th, that the Minister of Labour and National Service has made a new Essential Work Order, entitled the Essential Work (Coal-mining Industry) (Amendment) Order, 1942, which came into force on September 17th, 1942. The main provision under the Order is that it is an offence for a person employed in a scheduled undertaking to absent himself from work without reasonable excuse, or be persistently late in presenting himself for work, or fail to comply with any lawful and reasonable orders given to him, or persistently behave at work in such a manner as to impede the effective production of the work carried on in the undertaking. A person carrying on a scheduled undertaking may report to one of the new regional investigation officers of the Ministry of Fuel and Power that a person has acted contrary to the provisions of the Order in relation to any of these matters, and if the regional investigation officer is satisfied of the truth of the matter reported, he may, if he deems such a course to be necessary, recommend to a National Service Officer of the Ministry of Labour and National Service that proceedings should be instituted against the person who is the subject of the report.

Enemy Losses and British Shipbuilding

SPEAKING at the launching of a submarine a few days ago, Admiral Sir Max Horton said that British submarines had sunk 300 enemy supply ships, including many troopships, and had damaged nearly 50 more. Furthermore, our submarines had sunk or damaged 87 German and Italian warships, including more U-boats than were destroyed by British submarines in the whole of the 1914–18 war. Commenting on the relatively small number of enemy supply ships torpedoed, he reminded his audience that the number of such targets was small relatively to the shipping of the Allied countries, and that for the most part enemy tonnage moved in narrow and protected waters. In this connection, we may record a statement by the First Lord of the Admiralty in the House of Commons on September 9th that eleven of the shipyards closed by National Shipbuilders' Security, Ltd., were now in use for the building and repairing of all kinds of craft up to 10,000 tons deadweight and that twelve other yards closed between the two wars had been reopened. The policy of the Admiralty, said Mr. Alexander, was to open yards when there was labour to man them. Several thousand men had been returned from other industries to shipbuilding during the past eighteen months, and a further batch was being examined.

Employment Returns

IT was stated by the Ministry of Labour and National Service on Tuesday, September 15th, that the number of men and boys registered at employment exchanges in Great Britain as wholly unemployed at August 17th, 1942 (exclusive of 23,450 men who had been classified by interviewing panels as unsuitable for ordinary industrial employment) was 71,308; those registered as on short time or otherwise temporarily suspended from work on the understanding that they were shortly to return to their former employment numbered 1766; and those registered as unemployed casual workers (being persons who normally seek their livelihood by jobs of short duration) numbered 2548. As compared with July 13th, the numbers wholly unemployed showed a decrease of 260 among men, but an increase of 5452 among boys, the latter being mainly due to the registration of school leavers. Those temporarily suspended from work showed an increase of 38, and unemployed casual workers showed an increase of 368. The corresponding figures for women and girls at August 17th, 1942, were 36,226 wholly unemployed (exclusive of those, numbering 1122, who had been classified by interviewing panels as unsuitable for normal full-time employment), 1856 temporarily stopped, and 121 unemployed casual workers. Of the 36,226 wholly unemployed, 1146 had been classified as unable for good cause to transfer to another area. As compared with July 13th, the numbers wholly unemployed showed a decrease of 2974 among women, but an increase of 3880 among girls, the latter being mainly due to the registration of school leavers. Those temporarily stopped showed an increase of 320, and unemployed casual workers showed a decrease of 4.

Roumanian Oil

IN view of the statement that the Ploesti oilfields have been bombed recently by Russia, it is interesting to read in *The Economist* of September 12th that the output of the Roumanian oilfields has been declining steadily since 1936, when it reached the peak figure of 8·7 million tons. In 1941 production was already below 5½ million tons. Such a decline could not fail to arouse German anxiety, and though the German Press has only too eagerly blamed foreign capital for this decline, it could not help admitting that the irrational Roumanian oil legislation, which was entirely dictated by fiscal considerations, was mainly responsible for the decline. A new law of 1942 is said to render the business of oil prospecting and drilling more attractive for private capital than it was under the law of 1937. Hitherto, drilling firms were allowed to exploit only one-third of any newly discovered oilfield. The other two-thirds belonged to the State, and even on that first third the exploiting licence expired after two years. The risk for the *entrepreneur* was high, and the period of exploitation was, even in the case of successful prospecting, so short that it inevitably meant that oil operations were conducted wastefully. Apart from this, several concessions used to be granted for one oilfield. *Entrepreneurs* tended, therefore, to wait for the results of their neighbour's drilling before starting on any serious operations.

Delaware Aqueduct

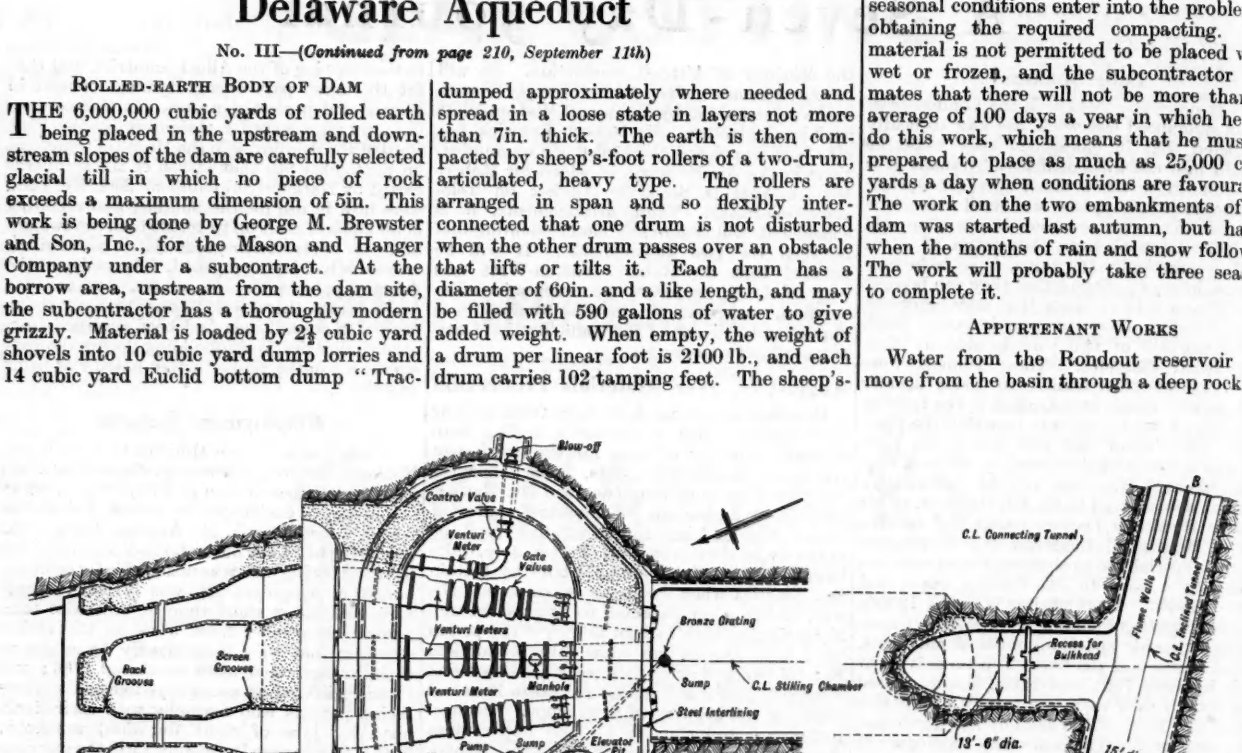
No. III—(*Continued from page 210, September 11th*)

Rolled-earth Body of Dam

THE 6,000,000 cubic yards of rolled earth being placed in the upstream and downstream slopes of the dam are carefully selected glacial till in which no piece of rock exceeds a maximum dimension of 5in. This work is being done by George M. Brewster and Son, Inc., for the Mason and Hanger Company under a subcontract. At the borrow area, upstream from the dam site, the subcontractor has a thoroughly modern grizzly. Material is loaded by 2½ cubic yard shovels into 10 cubic yard dump lorries and 14 cubic yard Euclid bottom dump "Trac-Truks," in which it is delivered to the grizzly plant. The plant is made up of two inclined revolving screens, with openings 5in. square. All rock which is rejected by these screens passes on through them and is loaded into lorries which haul it to the downstream toe of the dam for use in paving the slope. Material which passes through the revolving screens falls on a wide, slow-moving conveyor which feeds it on to a long rubber belt conveyor, which carries it to large loading hoppers. It is loaded by gravity from these hoppers into 10-yard lorries and 14-yard Euclid "Trac-Truks" for delivery to the embankment. At the dam the material is dumped approximately where needed and spread in a loose state in layers not more than 7in. thick. The earth is then compacted by sheep's-foot rollers of a two-drum, articulated, heavy type. The rollers are arranged in span and so flexibly interconnected that one drum is not disturbed when the other drum passes over an obstacle that lifts or tilts it. Each drum has a diameter of 60in. and a like length, and may be filled with 590 gallons of water to give added weight. When empty, the weight of a drum per linear foot is 2100 lb., and each drum carries 102 tamping feet. The sheep's-foot rollers are pulled in pairs, arranged in tandem. The total weight of a front unit when empty is 21,040 lb., the corresponding weight of the rear unit is a trifle less, and the unit pressure on the tamping feet—4ft. per drum in contact with the ground, each with an area of 6 square inches—is 438 lb. per square inch with a drum empty and 642 lb. per square inch when filled with water. The number of passes for each layer of material is variable, and depends upon the condition of the material at the time of placing and rolling. The specifications are definite as to the quality of the required material and its moisture content at the time of placing, and weather and seasonal conditions enter into the problem of obtaining the required compacting. The material is not permitted to be placed when wet or frozen, and the subcontractor estimates that there will not be more than an average of 100 days a year in which he can do this work, which means that he must be prepared to place as much as 25,000 cubic yards a day when conditions are favourable. The work on the two embankments of the dam was started last autumn, but halted when the months of rain and snow followed. The work will probably take three seasons to complete it.

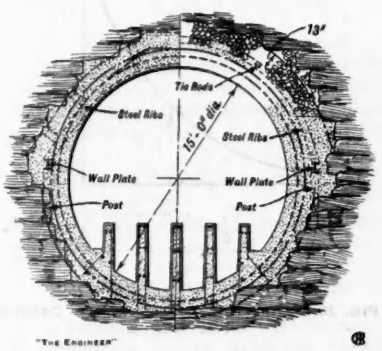
Appurtenant Works

Water from the Rondout reservoir will move from the basin through a deep rock-cut inlet channel to an effluent chamber, yet to be constructed, which will rise from a pit excavated in the rock to a depth of about 160ft. below ground surface. The rock excavated for the inlet channel and the effluent chamber has totalled 109,350 cubic yards. The effluent chamber will be equipped with six discharge lines for the control of outgoing water, fitted with screens, and with facilities for chlorinating the water if such be needed at any time. In the effluent chamber there is also a controllable blow-off line that will discharge into Rondout Creek, through the erstwhile diversion tunnel when no water is passing over the waste weir at



EFFLUENT CHAMBERS, STILLING CHAMBERS AND INCLINED TUNNEL

the south side of the reservoir. From the effluent chamber water will be discharged into two rock excavated stilling chambers, lined with concrete, that have each an inside diameter of 28ft. and a length of 80ft. The take-off from each stilling chamber is by a gooseneck outlet connecting tunnel at the top of the rear end, and is 13·5ft. in diameter inside the concrete lining. The two outlet tunnel sections connect with an inclined tunnel, through a transition section, that has an inside diameter of 15·5ft. The inclined tunnel has a length of 3200ft., and for all but 150ft., where it joins shaft 1 of the Delaware aqueduct, it has a 10 per cent. descending gradient. The lower third of the inclined tunnel is circular in section and has a finished diameter of 13·5ft., but the remaining two-thirds has a horse-shoe shape cross section with a maximum diameter of 15·5ft. The invert of the horse-shoe section of tunnel is divided by five reinforced concrete walls, about 4ft. high, into six longitudinal flumes for the purpose of steadying the flowing water and robbing it of some of its momentum before being discharged into shaft 1 at an elevation of approximately 438ft. down from the collar of that shaft, which has a total depth of 982ft. At the intersection of the inclined tunnel with shaft 1 the shaft is chambered out to a diameter of 40ft. and for a height of 40ft., with conical transition sections above and below, tapering to the prevailing 14ft.



SECTION THROUGH INCLINED TUNNEL

diameter of the shaft. At its bottom the shaft joins the first section of the deep pressure tunnel of the aqueduct. This tunnel has an inside diameter of 13·5ft., and the section in question, now being driven, will have an approximate length of 5200ft.

The inclined tunnel was driven by the top-heading and bench method, and was driven from shaft 1 up hill to the connections that were made with the two stilling chambers. The slope of the tunnel was too steep for the use of storage battery locomotives to move the muck trains, and a scraper type of electrically driven mucker was employed at the heading. The muck trains were pulled up hill empty by a double-drum hoist, and the trains, controlled by the hoist, were moved down hill by gravity to the shaft end of the tunnel, where loaded cars, one by one, were run on to a cage platform in the shaft and hoisted, loaded, to the tipple in the head frame. The inclined tunnel was holed through at its upper end in August of 1941, and since then the work of placing the concrete lining has gone steadily forward. This operation has progressed from the lower end of the tunnel up hill, with the concrete being delivered from the upper end and not from shaft 1. The following particulars have been furnished the writer by Mr. Ribble :—

"The only unusual feature in connection with the lining of the 13·5ft. circular section of this tunnel was the transportation of concrete on the 10 per cent. gradient. The concrete was mixed at a plant located near the effluent chamber end—the up-gradient end of the inclined tunnel. A short belt conveyor carried the concrete from the mixer to the top of a 10in. drop pipe that was placed in a hole previously drilled through the rock above the end tunnel to a depth of about 130ft. The concrete is dropped from the end of the belt to a hopper at the tunnel level. This hopper is high enough to allow the 4·5 cubic yard agitator cars to pass beneath it as they are loaded by gravity from the hopper. The agitator cars are then lowered, also by gravity, down the tunnel track to a Pumpcrete machine equipped with a rotary remixer. The unit was first located 1300ft. from shaft 1 and from the first form, and the distance was shortened each day by the 60ft. length of pour as advance was made up-gradient towards the machine.

"The most difficult operation has been the placing of concrete in the 15·5ft. horse-shoe section, the longer stretch of the inclined tunnel. There we have used two forms, one for the invert and flume walls which are poured monolithically, and another for the side walls and arch. The flume walls are heavily reinforced, and it was specified that only ¾in. gravel should be used for the concrete placed in them. This has necessitated changing the concrete mix at the point at which the main invert was completed and the flume walls started. Concrete for the invert and flume walls has been transported, as was done for the circular section of 13·5ft. tunnel. The Pumpcrete pipe discharged the concrete on a flat platform that was moved along the tunnel axis on rails anchored to the top of the invert flume wall form. At the down gradient end of this platform five openings were provided, one over each of the five flume walls and one opening at each side. Short chutes directed the concrete to each flume wall from these openings and to the sides. The openings could be opened or closed so that the placing of concrete into any or all of the wall was under control. As concreting advances, the platform is moved up hill by a small air tugger hoist, mounted at the rear, of the steel form. Another and larger air hoist is also mounted at the rear of the form for moving both the main form and the platform.

"All reinforcing steel is placed prior to moving up the form; 6in. angles are placed at 15ft. intervals at right angles to the axis of the tunnel and anchored at each end to the concrete kerb walls. Their elevation is such that they are beneath the C line of the invert. The vertical reinforcing rods are welded, in proper alignment, to these angles and the horizontal rods are wired to the vertical angles. The intermediate vertical rods are wired to the horizontal rods. After moving the form up into place, concrete blocks of the required thickness are wired to the rods at top and bottom of the flume wall form to assure proper distance between rods and forms. A good job of wiring is needed to hold the rod mats together, because they are continually exposed to vibration due to the impact of the concrete as it is dropped. However, generally very good results have been obtained. There has been little or no honeycomb in the flume wall concrete, and the alignment of the five walls is almost perfect. We have placed a 60ft. length of tunnel each day, pouring the concrete on the eight to four o'clock shift, setting rods for the next pour on the four to twelve o'clock shift, and moving and setting the form on the twelve to eight o'clock shift. The arch form is carried on a track that is supported by wooden ties resting on the tops of the flume walls, and we are placing 60ft. of arch per twenty-four hours. Work on the effluent chamber has been halted, due to inability to procure materials of bronze, brass, and steel, owing to the pressure of national defence demands.

"An interesting feature of the placing of rolled embankment which was started last summer is the drainage system. After completing the core wall the cut-off trench was thoroughly cleaned of loose earth, and, following grouting, the deep-well pumps and the pumps in exploratory caissons A and B were stopped. This resulted in a rise of ground water level above the bottom of the cut-off trench. Obviously, it was necessary to control this water before placing any of the rolled embankment. For this purpose, the first step was to construct sumps about 10ft. square and 10ft. deep below the bottom of the trench. Two such sumps were provided, one on each side of the core wall and directly opposite each other, alongside caisson No. 10, the middle caisson. The sumps were walled with steel sheet piling, and inside each sump were placed the bowls of deep-well pumps, and the shafts extended up to the pumps which were set on a 24in. beam, secured at right angles to the axis of the dam at the top of the cut-off wall above caisson No. 10. The

FLUMES IN INCLINED TUNNEL

beam was long enough to secure the pumps at each end directly above the centre of the respective sump. Starting at the bottom of the sumps, corrugated iron shafting formed a shell around the pump shafting, and this shell, in unit lengths of about 2ft., consisted of two semi-circular pieces which, when fastened together, became a shaftway 4ft. in diameter. The shafting extends above the elevation of the cut-off trench and continues upward as the rolled embankment is placed, thus serving as sumps which can be used until the rolled embankment reaches the elevation of the original ground surface. A complete drainage system was installed over the bottom of the cut-off trench throughout its entire length, and discharges into the sumps on each side of the core wall. The drainage system is made up of longitudinal and lateral vitrified clay tile, 10in. in diameter, laid with open joints surrounded by 1½in. crushed gravel. The elevation of the pipes is from 2ft. to 3ft. below the elevation of the bottom of the cut-off trench, and the trenches for the drainage system were back-filled with crushed gravel. The pumps were operated continuously, including Sundays and holidays, and in a short time the cut-off trench was sufficiently dry to begin placing the rolled embankment. Approximately 300 gallons of water per

minute were pumped from the two sumps as long as the pumps were operated. Approximately two weeks after the placing of the rolled embankment was discontinued for the winter season, the pumps were stopped, and about two weeks later the top of the rolled embankment was covered with water. Pumping will be resumed this year when conditions are favourable for the resumption of work on the rolled embankments, and it is believed that ground water can be lowered and controlled by means of this drainage system."

The dam and all associate features were designed and are being built under the supervision of the Board of Water Supply of the City of New York, with Charles M. Clark, chief engineer; James A. Guttridge, department engineer; N. Le Roy Hammond, division engineer; Charles G. Hoerner, senior section engineer; and Herbert A. Dibbell, section engineer. The work is being done by Mason and Hanger Company, Inc., of which Arthur J. Sackett is president, Miles I. Killmer vice-president, Howard L. King chief engineer, and John M. Ribble job manager. Until recently William R. Ury had been superintendent.

(To be continued)

The Electric Arc Furnace

By T. F. WALL, D.Sc., D.Eng.

No. IV—*(Continued from page 218, September 11th)*

Skin Effect in the Leads of an Electric Arc Furnace

THE influence of skin effect on the ohmic resistance of a conductor may be seen from the following example:—Consider a metal plate of thickness $2a$, of which Fig. 19 shows a sectional view, and suppose that an alternating current is flowing in a direction perpendicular to the plane of the paper. The electromagnetic action of the current will cause a non-uniform distribution of the current

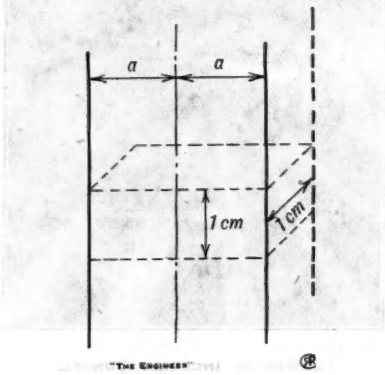


FIG. 19—SECTION OF METAL PLATE

throughout the section, so that the maximum current density will be found at the surface boundary of the plate.* Assume that the current density within the body of the plate varies exponentially with the distance from the boundary, as shown in Fig. 20, and that the surface current density is i_o, the current at any distance from the surface being then assumed to be given by the expression

$$i_x = i_o \epsilon^{-\frac{2 \cdot 8}{a} x} \quad . \quad . \quad . \quad . \quad (4)$$

so that at the central part of the plate, that is, for $x=a$,

$$i_x = i_o \epsilon^{-2 \cdot 8} = 0 \cdot 06 \, i_o.$$

and is thus negligibly small.

It has been shown in a previous article† that expression (4) gives the "penetration" in this case as

$$\delta = \frac{a}{2 \cdot 8}.$$

The mean current density throughout the plate will then be i_m where

$$i_o \, \delta = i_m \, a \quad . \quad . \quad . \quad . \quad . \quad (5)$$

Now if ρ be the specific resistance of the material of the plate and ρ' be the specific impedance for the given frequency of A.C then, since the same pressure V acts across every part of the section of the plate, it is easily shown that

$$V = i_m \rho' = i_o \rho \quad . \quad . \quad . \quad . \quad (6)$$

so that combining equations (5) and (6) it follows that

$$\frac{\rho'}{\rho} = \frac{i_o}{i_m} = \frac{a}{\delta} = 2 \cdot 8 \quad . \quad . \quad . \quad . \quad (7)$$

since

$$\delta = \frac{a}{2 \cdot 8}.$$

Hence for this particular numerical example

$$\frac{\text{Impedance to A.C.}}{\text{Resistance to D.C.}} = 2 \cdot 8.$$

The efficiency of the electric arc furnace and the amount of energy which can be converted into useful heat in it depends not only upon the structure of the arc itself, but also on the size and chemical composition of the electrodes and upon the arrangement and design of the connecting leads from the transformer to the electrodes. The shape and dimensions of the electrodes determine the uniformity of the current distribution throughout the section, whilst the chemical composition determines the resistance losses and consequently the amount of wasted heat. Although the arc current is usually taken from the normal supply system of which the frequency will be 50, yet, owing to the necessarily large dimensions of the leads for carrying the enormously heavy currents of the arc, which, in the case of reduction furnaces, may reach a value of 300,000 amperes, serious losses due to skin effect may be produced if the design of the conductor leads is not carefully examined from this point of view. In order to eliminate skin effect and to ensure an approximately uniform current density throughout the cross section of the electrodes, experience has shown that it is advisable to keep the radius of a circular electrode less than $\frac{1}{\beta}$ where

$$\frac{1}{\beta} = \frac{1}{2 \pi} \sqrt{\frac{\rho \times 10^9}{f \cdot \mu}} \text{ cm.} \quad . \quad . \quad . \quad . \quad (8)$$

In this expression f is the frequency of the alternating current in cycles per second, μ is the magnetic permeability of the conductor, and ρ is the specific resistance of the material of the conductor in ohms per centimetre cube.

The quantity $\frac{1}{\beta}$ is the same as the penetration depth δ, as previously considered,‡ so that the current density in the conductor at any depth x, when $\frac{d}{2}$ is relatively large —see Fig. 21 may be written

$$i_x = i_o \epsilon^{-\beta x} \quad . \quad . \quad . \quad . \quad . \quad . \quad (9)$$

where i_o is the current density at the surface.

From this expression it is seen that the quantity β is a damping factor.

For copper conductors at about 20 deg. Cent., $\mu=1$ and $\rho = \frac{1 \cdot 7}{10^6}$ ohm per centimetre cube, so that

$$\beta = 2 \pi \sqrt{\frac{f}{1 \cdot 72 \times 10^3}} = 0 \cdot 151 \sqrt{f}.$$

For alternating current at 50 frequency the damping factor is $\beta=1 \cdot 07$, and if the frequency is 200 the value of the damping factor is $\beta=2 \cdot 14$.

For the graphite electrodes of an electric arc furnace operating at 50 frequency, the specific resistance may be taken to be

$$\rho = 1 \cdot 5 \times 10^{-3} \text{ per centimetre cube}$$

so that

$$\frac{1}{\beta} = \frac{1}{2 \pi} \sqrt{\frac{1 \cdot 5 \times 10^6}{50}} = 28 \text{ cm.}$$

It may therefore be assumed that practically uniform current density throughout

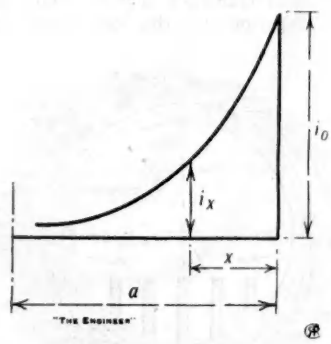


FIG. 20—VARIATION OF CURRENT DENSITY WITH DEPTH

the cross section will be obtained if the diameter of the graphite electrodes is not greater than about 50 cm. (20in.). If exceptionally heavy currents are required, so that a large section of electrode becomes necessary, then either the circular shape must be abandoned for a rectangular shape or the permissible current density must be so reduced that the skin effect will not produce serious resistance losses.

A non-uniform current density in the leads to the furnace is particularly to be avoided, since in such a case excessive heating may be developed to such an extent that the reliability of operation of the plant may be seriously endangered. Non-uniformity of current distribution may also mean that the conductor material is not being economically utilised.

Non-uniformity of current distribution in a conductor carrying alternating current can be referred to the absorption of energy of the electro-magnetic waves in the metal. The electric flow in the conductor is of a wave character, and if the conductor be assumed to be of a rectangular shape of a given height h cm., then it is possible to calculate the most suitable thickness of conductor for which a practically uniform current distribution can be obtained. In such a calculation it is necessary to take into account the reflection effect at the boundaries of the conductor. It is to be observed that two distinct typical cases have to be considered, as follows:—

(i) In the first case the "go" and "return"

* See THE ENGINEER, March 6th, 1942

† See THE ENGINEER, March 6th, 1942, page 210, equations (3) and (4).

‡ See "High-Frequency Induction Furnaces," THE ENGINEER, March 6th, 1942, p. 209.

leads may be assumed to be parallel to each other and spaced not far apart, as illustrated in Fig. 21. In this case practically the whole of the magnetic flux will be concentrated between the two conductors, as shown in the diagram, so that the skin effect will only develop on those sides of the conductors

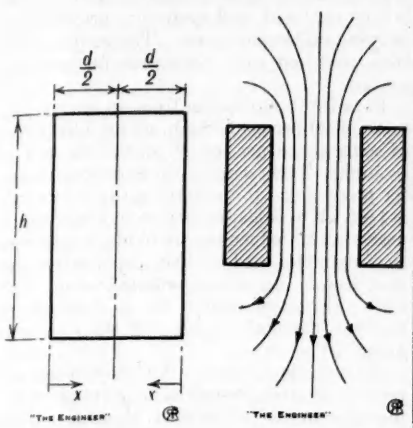


FIG. 21—MAGNETIC FLUX DISTRIBUTION

which are facing each other. In this case the ratio of the A.C. resistance to the D.C. resistance is given by the formula

$$\frac{R_{A.C.}}{R_{D.C.}}=\frac{\beta d}{2}\left[\frac{\sinh \beta d+\sin \beta d}{\cosh \beta d-\cos \beta d}\right] \quad . \quad (10)$$

where d is the width of the conductor.

It will be seen that if the quantity in brackets is divided top and bottom by $\cosh \beta d$, then it tends towards the limit 1, when βd is very large, so that in the limit

$$\frac{R_{A.C.}}{R_{D.C.}}=\frac{\beta d}{2} \quad . \quad . \quad . \quad . \quad . \quad (11)$$

and since the resistance to direct current will be

$$R_{D.C.}=\frac{\rho}{h \,.\, d} \text{ per centimetre length}$$

of the conductor, it follows that the resistance to alternating current when the thickness d is very great will be

$$R_{A.C.}=\frac{\rho \beta}{2 h} \text{ per centimetre length}$$

of conductor as stated already.

Fig. 22 shows the values of the resistance to A.C. at 50 frequency, and the resistance

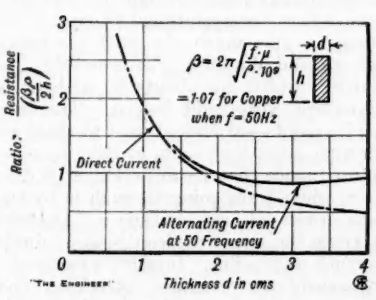


FIG. 22

to D.C. respectively for various values of the thickness d of the rectangular conductor, the scale for the ordinates being given in terms of this quantity $\frac{\rho \beta}{2 h}$. For D.C. the resistance will be $\left(\frac{\rho}{d \,.\, h}\right)$ ohm per centimetre length of conductor.

The expression (10) may be rewritten in the equivalent form

$$\frac{R_{A.C.}}{R_{D.C.}}=\frac{1+\frac{(\beta d)^4}{\underline{|5}}+\frac{(\beta d)^8}{\underline{|9}}}{1+2\frac{(\beta d)^4}{\underline{|6}}+\frac{(\beta d)^8}{\underline{|10}}} \quad . \quad . \quad (12)$$

and for many practical cases this latter form will be found to be the more convenient one for purposes of calculation.

A remarkable and interesting fact which emerges from these results is that there is a certain thickness for the rectangular conductor for which the A.C. resistance is a minimum, and for the case for which the curves of Fig. 22 have been obtained this minimum thickness is about $d=2{\cdot}75$ cm. This phenomenon was first pointed out by Rogowski.

(ii) The second extreme case is that represented in Fig. 23, in which the "go" and "return" leads are spaced at such a distance apart that the magnetic flux may be considered to be more or less uniformly distributed round the conductor, so that the skin effect will develop on both sides of the rectangular conductor section. The value of the A.C. resistance in this case will be given by the expression

$$\frac{R_{A.C.}}{R_{D.C.}}=\beta d\left[\frac{\sinh 2\beta d+\sin 2\beta d}{\cosh 2\beta d-\cos 2\beta d}\right] \quad . \quad (13)$$

which may be rewritten in the equivalent form

$$\frac{R_{A.C.}}{R_{D.C.}}=\frac{1+\frac{(2\beta d)^4}{\underline{|5}}+\frac{(2\beta d)^8}{\underline{|9}}}{1+2\frac{(2\beta d)^4}{\underline{|6}}+\frac{(2\beta d)^8}{\underline{|10}}} \quad . \quad . \quad (14)$$

Fig. 24 shows the values of the A.C. resistance at 50 frequency and D.C. resistances respectively for various values of the thick-

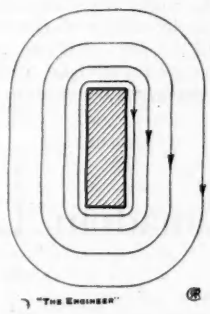


FIG. 23—MAGNETIC FLUX DISTRIBUTION

ness d cm. of a rectangular conductor when the "go" and "return" conductors are far apart.

Fig. 25 shows the values of the ratio $\frac{\text{A.C. resistance}}{\text{D.C. resistance}}$ for various values of the product of the damping factor β and the thickness d cm. of a rectangular conductor for each of the cases (i) and (ii). An inspection of the graphs in Fig. 25 will show that in each of the cases (i) and (ii) the ratio of the A.C. and D.C. resistance approaches a straight line through the origin, viz., in case (i) the slope of the straight line is given by $\tan \alpha_i=\frac{\beta d}{2}$. In case (ii) the slope of the straight line is given by $\tan \alpha_{ii}=\beta d$. It will also be seen that in each case the thick line curve approaches the corresponding straight line by means of a wave form.

THE MANUFACTURE OF CALCIUM CARBIDE

The manufacture of calcium carbide forms one of the oldest electro-thermal reduction processes and to-day there are many electric arc reduction furnaces for this purpose in operation of a capacity of 20,000 kW and upwards. During the last few years this type of furnace has achieved immense importance in the chemical industry, particularly for the manufacture of synthetic products, such as alcohol and acetone and also for artificial rubber, for which calcium carbide forms the basic material. Calcium carbide is also used for the manufacture of calcium nitrate, which is a valuable form of chemical manure.

In combination with nitrogen, calcium carbide forms calcium cyanimide (nitrolime).

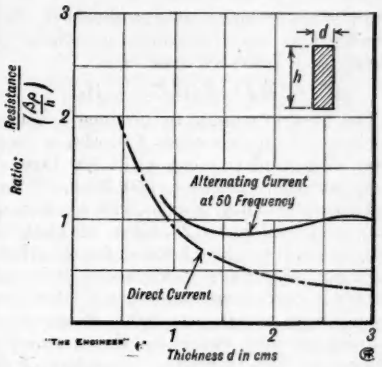


FIG. 24.

This substance is used as a soil fertiliser and when acted on by the water of the soil is resolved into ammonia and carbonate of lime. Since the presence of ammonia in the soil is essential for promoting vegetable growth, the manufacture of nitrolime has become an enormously important industry. The nitrogen required for this purpose is prepared from liquid air, which contains almost exclusively liquid oxygen and liquid nitrogen. These constituents can be separated by reason of their different boiling points, since the nitrogen distils first. The nitrogen is then passed into intensely heated calcium carbide to form calcium cyanimide ($CaCN_2$).

The raw materials for the production of calcium carbide are coal and lime, and these

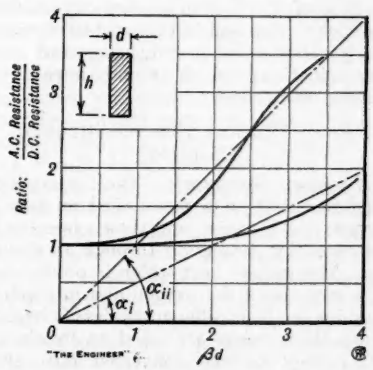


FIG. 25

substances are found in almost unlimited quantities in many countries and are obtainable at a very low cost. Some idea of the industrial and economic significance of the electric arc furnace is obtained when it is observed that by its means it is possible to use these cheap materials as the base for the manufacture of such valuable commercial products as rubber and acetylene.

It is now an economical process to use electric arc furnaces for the manufacture of calcium carbide even when the electric energy is obtained from steam-driven power stations

which use fairly good quality coal, involving a relatively high price for the electric supply. In order to obtain advantage of the cheap electrical energy obtainable by means of water power, calcium carbide furnaces were formerly erected near the sources of water power. This, however, is no longer necessary, since in many countries the national electric supply grid gives a wide choice for the site of such furnaces.

When coke and lime are mixed together and raised to a suitably high temperature, chemical action takes place in accordance with the equation

$$CaO + 3\,C = CaC_2 + CO.$$

The calcium carbide (CaC_2) so obtained, when immersed in water, produces acetylene gas (C_2H_2) and hydrated lime, viz.,

$$CaC_2 + 2\,H_2O = CaH_2O_2 + C_2H_2.$$

The electric energy to produce 1 ton of calcium carbide in modern factories is about 3000 kWh, and this can yield 300 litres of acetylene gas. Further, 950 kilos. of lime and about 600 kilos. of coke, with a consumption of 15 kilos. to 25 kilos. of electrode material, will produce 1 ton of fused carbide. Each ton of carbide yields about 400 cubic metres of carbon monoxide gas (CO) of heat value from 2500 to 3000 kilogramme-calories per cubic metre, and this is generally allowed to burn to waste. Some idea of the economies which are still awaiting realisation is obtained when it is observed that the utilisation of this heat would make possible the saving of from 300 kWh to 400 kWh of electric energy per ton of carbide—that is, a reduction of the energy of manufacture (viz., 3000 kWh) by about 10 to 15 per cent. A further gain would be that the chemical reactions in the furnace would be more satisfactory and the attendance service would be simplified.

Ferro-alloys, viz., ferro-silicon (50 per cent. silicon), ferro-manganese, ferro-chrome, and ferro-tungsten, are manufactured in the same constructional type of furnace as is used for the manufacture of calcium carbide, except that the hearth lining is different. These alloys are used in steel works for the purpose of refining the molten iron and in order to produce high-quality steel. The most extensively used is ferro-silicon, the purpose of which is to extract oxygen from the molten iron and in this way to eliminate the possibilities of slag inclusion and other contaminations which would impair the quality of the steel.

Some Further Electro-thermal Processes

Nitrogen Compounds.—The atmosphere consists chiefly of a mechanical mixture of oxygen and nitrogen, and these gases can be combined by passing air through an electric arc. The intense heat which is produced in this way causes the oxygen and nitrogen to combine and form different oxides of nitrogen. When these oxides are acted on by air and water they become converted into nitric acid, and this acid can then be combined with soda or with lime to form nitrates of sodium or calcium. These nitrates are very important fertilisers, and are essential for successful soil treatment for agricultural purposes, whilst nitric acid is an essential ingredient in all kinds of explosives.

Sodium nitrate ($NaNO_3$) occurs in nature as Chile saltpetre, and potassium nitrate (KNO_3) as nitre or ordinary saltpetre. Since the natural deposits of Chile saltpetre in Bolivia and Peru are quite inadequate for the world's continually increasing requirements, much attention has been given to methods of so-called "fixing" the atmospheric nitrogen for the purposes of obtaining nitric acid. One such process has been carried out on an immense scale in Norway by means of electric furnaces. An electric alternating current arc is formed in a narrow chamber and by the action of a magnetic field this arc is spread out into a thin circular sheet of flame. Air is forced through the arc and a certain proportion of the nitrogen is in this way converted into nitrogen oxides. The heated gases are quickly cooled and passed into a tower packed with lumps of quartz or granite down which water is allowed to trickle. The result is the formation of dilute nitric acid which is then combined with lime to form calcium nitrate ($CaNO_3$). Since this method only effects the combination of a small fraction of the nitrogen and oxygen in the air which is passed through the arc, it is not sufficiently economical to operate, except in situations where electricity can be obtained at a very low cost from water power.

Another process has, however, now been developed which is free from the objection of low efficiency. The essence of this method is the production of ammonia by causing hydrogen and nitrogen to combine under immense pressures—up to about 1 ton per square centimetre—and passing the gases, over catalysts which cause the hydrogen and nitrogen to combine to form ammonia. It has been found possible to obtain the combination of 30 per cent. of the hydrogen which is treated in this way.

Reduction of Tin Ore.—A very important application of the three-phase electric arc furnace is for the reduction of ores for which only moderate temperatures are necessary, viz., up to about 1200 deg. Cent. A good example of this application is the reduction of tin ore. The metal as used in industry is extracted entirely from "tin stone" or "cassiterite" (SnO_2), large deposits of which are found in South America. For reducing this material by means of the arc furnace, about 1200 kWh per ton of ore are required, with a consumption of about 8 kilos. of electrodes, the electrodes being arranged for indirect heating in accordance with the principle illustrated in Fig. 3. After the ore has been picked, cleaned, crushed, and washed, the resultant concentrate contains about 90 per cent. of SnO_2. This is mixed with wood charcoal as a reducing agent, and certain ingredients for separating out the impurities, and is then melted in the furnace. The furnace is fully enclosed, and means are provided for drawing off the hot gases. The molten tin is then remelted in a resistance furnace and refined.

In order to reduce tin from an ore concentrate of 90 per cent. SnO_2, about 1400 kilos. of concentrate per ton of molten tin will be required. Theoretically, the energy necessary for producing 1 ton of molten tin in this way is 1100 kWh, this quantity including the heat necessary to reduce the tin oxide, to separate the impurities, and to cover vaporisation and dust losses. In actual practice, about 1680 kWh per ton of molten tin is required, so that the thermal efficiency of the process is about 70 per cent.

Aluminium Cement.—An electro-thermal process of great industrial importance is the manufacture of aluminium cement. When bauxite and quicklime (CaO) are fused in the electric arc furnace, an aluminium cement is produced which has the advantage over ordinary cement that it sets very quickly and can even be used in frosty weather. In one factory alone a three-phase electric arc furnace of 2000 kW input is used to produce 60 tons of this cement daily.

Acknowledgment is made to the booklet "Siemens Lichtbogenöfen für die Eisen-und Stahlindustrie," published by the Siemens-Schuckert Works, Berlin, for the originals of three of the illustrations included in these articles and for technical data relating to the Siemens and Halske electric arc furnace. An English translation of this booklet has been published by Siemens-Schuckert (Great Britain), Ltd.

Canadian Locomotive Experiences

By EDWARD H. LIVESAY

No. III—(*Continued from page 213, September 11th*)

Canadian Pacific Railway, Transcontinental, Return: Regina to Winnipeg

CALGARY is the gateway to the prairie, that vast wheatfield extending 900 miles to beyond Winnipeg; the gently rolling plain across which stretches the main line of the C.P.R., descending almost uninterruptedly—apart from one or two little elevations between river valleys—down, down from 3438ft. at Calgary to 766ft. at Winnipeg. During the half century since the railway was built, Calgary has developed from a primitive cattle town, the stamping ground of rancher, remittance man and cowboy, into a sophisticated city of 100,000 people, and has become a railway centre, from which branch lines radiate in all directions, like the spokes of a wheel.

The eastbound "Dominion" leaves at 8.15 p.m., but on this occasion it did so minus the present recorder, who was going up north on "The Chinook," as has been told in a previous article. He planned to rejoin the "Dominion" at Regina, 475 miles farther along the line, several days later, and to reach that point by going round three sides of a square, having Edmonton and Saskatoon at its two upper corners. By so doing he side-stepped several hundred miles of main line, but missed little of scenic or operational interest, because things are very much of a muchness between Calgary and Winnipeg; it is mostly "bald prairie," which hereabouts is, without peradventure, very bald indeed. The prairie has its points—at least, I used to think so at one time—but they seem to have become so blunted since that I can no longer find any. Now, when I am going through it by train, even in the cab, my attitude is "the sooner it is over the sooner to sleep"—and I do sleep as much as possible. Imagine a tremendous, apparently never-ending, treeless, naked plain, a patchwork quilt of unfenced, rectangular fields of wheat, oats or grey-green grass—"prairie wool"—dotted here and there with little clusters of wooden buildings, house, barn, sheds, and "other offices," as the house agent has it, unpainted, bleached, and drab, often leaning at an angle, the Lord *not* having "tempered the wind to the shorn farm," but apparently the reverse. These architectural abortions surround a barnyard littered with neglected machinery, old and new, left out in the open for rust and moth to corrupt, and for the first cyclone that comes along to break up and steal, and

deposit in the next province, a thing which is likely to happen at any time. That is a typical prairie farm, as seen from the train. A mile or so away, in any direction, are others like unto it, and so on into infinite distance, a world without end. As for the towns and villages, read Sinclair Lewis's "Main Street" for a description of these beauty-lover's nightmares. Occasionally a dirt road is seen, running from out of nothing unto nowhere, dusty, stark, projected to infinity, shaded with telephone poles instead of trees, a perfect example of the Euclidean definition of a straight line as understood on the prairie: "the shortest distance between two points, neither worth looking at, having position but no importance, bounded by space, all without form, and void." Such is the bald prairie, inspiring in the observer visions of immensity, monotony, loneliness, isolation. Even in summer it can be a weariness unto the flesh, with a temperature known to have reached 114 deg. in the non-existent shade; but picture it in winter, a silent, measureless, glittering white waste, held in a steely grip by possibly seventy or more degrees of frost, which you must fight, and beat, or you die! That, too, is the prairie, and that is what Hitler's "accursed locusts" have been cowering under on Russian steppes. But enough—we have skipped 475 miles of this sort of thing, and are picking up the trail again at Regina, the capital of Saskatchewan, another railway centre.

From Regina

The "Dominion" left at 8.33 a.m., eight minutes late, headed by "No. 2832," one of the ubiquitous "2800" class, 4–6–4, in charge of Enginemen Henze and Hubbard; it was made up of thirteen cars, say, 950 tons. The weather was dull, but dry, after heavy rain, and the get-away was quick, though the engine was not fitted with a booster. Steam was at blowing-off point, 275 lb., the exhaust pressure gauge handling the truth carelessly, as it is sometimes apt to do, by registering 20 lb. The gradient out of Regina is decidedly adverse as far as McLean, 24 miles, the rise being 390ft.; it was taken on the usual two-thirds throttle, but with the cut-off lengthened to 35 per cent. on the steepest part of the incline, the speed falling to 45 m.p.h. It was strange to note down these figures, and to feel the engine working quite hard on an eastbound train; one generally thinks of the lie of the land as a steady fall from the Rockies to Lake Superior. But it is really not quite so uniform as this; there are one or two stretches of rising track on the main line, and this piece between Regina and McLean is, I believe, a ruling gradient, and one of the heaviest.

The C.P.R. main line is well cared for and the riding of "No. 2832" was good. Steel is 100 lb., and there is, I have been told, a blanket speed limit of 75 m.p.h. on the prairie; train schedules are such that this figure seldom has to be exceeded. However, if a little time must be made up, the limit would probably be honoured as much in the breach as the observance. I cannot imagine the average engineer being ultra-punctilious and holding strictly to the letter of the law if he wanted to overstep the limit by a few miles per hour, or suffering from a guilty conscience subsequently.

The line runs through the great alkali belt, the plain being dotted with lakes and pools—"sloughs," as they are called—their margins encrusted with white salts, giving the water a sweetish taste, and having very often the most undesirable effect on man, beast, and locomotive boiler. The "2800s" working on the prairie are fitted with special blow-down cocks that are opened every 10 or 15 miles, though I was told that an automatic device is being tried out, and that good reports of it had been received. Possibly this is the "Foam-meter" described in the C.N.R. "Continental" article of April 18th, 1941. I do not think water softening or purifying plants are used on the prairie, though compounds are added to the tender supply.

The 24 uphill miles to an unscheduled coaling stop at McLean were covered in 35 min., 41 m.p.h., moderate work with a 950-ton train. Referring to the mechanical stoker, a fitting that always interests me, Hubbard mentioned that if it should fail entirely, as is, of course, possible, though rare, an extra man is provided at the first opportunity, as one man could not possibly hand-fire such a big box as this—81 square feet—for long. The mechanical stoker is one of the most prominent features in the cab of a large American engine, and on its reliability depends the utilisation of the engine's full capacity. During many thousands of miles travelled on stoker-fired engines nothing of importance in my experience has ever gone wrong with the stoker mechanism; it has always been absolutely reliable. Occasionally an extra large lump of coal has blocked the opening to the conveyor, and has had to be cleared away by hand, but beyond that nothing has ever occurred to interrupt the cascade of fuel into the fire-box. A chunk of wood or iron may jam the conveyor, in which case reversing should clear it away, but in the event of this being found impossible, the coal can still be shovelled on to the shelf upon which the conveyor normally deposits it, below the fire-door, the steam jets then picking it up and spreading it as usual. One or two firemen have "let on" to me that they could hand-fire an 80 square foot box, but this puts a considerable strain on my credulity (a delicate way of phrasing it). Much would depend on the gradients, load, and how long they tried to keep things going. I am convinced it could not be done indefinitely, or over any but easy gradients. These musings arose from the fact that the stoker pressure gauge, or its connections, here became unreliable. It has two hands, one showing the pressure in the stoker engine, and the other in the jets. In this case they showed 50 lb. and zero respectively—both readings were incredible. Some such little triviality as this is the worst I have ever had to complain of in the stoker or its fittings. It is far from being a crude or extravagant arrangement; on the contrary, it does its work with efficiency and economy, and the result is, I am sure, at least as satisfactory as hand-firing, particularly when the engine is working hard, and a great deal of fuel has to be fed to the fire-box rapidly. The steady, unvarying feed of the mechanical stoker, and the even distribution of the coal over the grate, is a decided asset under these circumstances.

Once over the top of the incline, and away after the coaling stop at McLean, the speed rose rapidly, Qu'Appelle being passed at 75 m.p.h.; Henze was evidently trying to pick up those eight elusive minutes. He succeeded in recovering several of them before stopping at Indian Head to take water, getting away at 9.32. The 42 miles from Regina, including the stiff climb to McLean and the coal stop there, had taken 55 min., 46 m.p.h. With 950 tons I have seen worse running.

Single track begins again at Indian Head, continuing to Grenfell, and the automatic colour-light signals became of increasing interest. Their messages were all repeated across the cab *viva voce*, green bringing the hail "Clear Board!" meaning that the signal was off; "Red Board," it was on; and yellow meant that it was the equivalent of distant or permissive. The Indian Head country is one of the oldest settlements in Saskatchewan, and is noted for its great experimental farm. The sooty-black soil is very deep and rich, the plain hereabouts being dead level as far as the eye can reach, and the waving green wheat looked vividly green after recent heavy rains. The speed was again in the 70s, which was hit and held for a considerable distance, through Sintaluta and Wolseley—named after Lord Wolseley, who in his early days commanded the Red River Expedition of 1870 that put down the Riel Rebellion. The next divisional point, Broadview, was reached at 10.35 a.m., on time, the 93 miles from Regina, including three stops, having been covered in 122 min., 46 m.p.h., which is fairly representative of prairie running, and shows it can be seldom much under 60 m.p.h. At Broadview clocks are put on an hour, and Central time worked to. The usual servicing was done, always carried out at divisional points; grease-gun lubrication, ashpan cleaning, made simple with side and bottom doors, and so on. Enginemen Clarke and Buchanan took over here—the former a "Royal Train" man, and a previous acquaintance—the latter keen to have the latest news of Twickenham, his native heath. I was able to reassure him that it had been going strong quite recently, and that it would undoubtedly continue to do so until, and long after, Hitler enters an asylum. "Which pleased him mightily," *à la* Pepys.

The "Dominion" got under way again at 11.50, by the new Central time, and was soon running again at the usual fairly high speed. On the prairie there is seldom much to look at outside the cab, so I concentrated on making as many notes as possible inside. The air whistle concerned me—by means of which the conductor (guard) communicates with the people in the cab. It is a handy arrangement, various routine messages being passed along by it, indicated by a code of blasts, such as "Stop," "Start," "Stop next station," "Test brakes," and so on. One fireman courteously lent me his "Book of the Rules" containing the whole gamut, which I carefully noted down—and then lost. I wonder if this whistle might not be worth trying in Britain? Or do guards in England never have occasion to get ideas into drivers' heads *en route?* It is possible to think of times when this might be desirable, or even vital, and in this case the absence of any means of doing so, short of stopping the train, could cause trouble. Some day I suppose a telephone will be considered a *sine qua non*, but at present this appears to be a counsel of perfection, only to be provided on exceptional occasions. I have noticed several little devices standard on American engines that might come in equally useful in Britain if they were only known there. Rocking grates are looked upon as essential over here, on this side of the Atlantic, but the kind of coal used no doubt accounts for this. In England I know they are not always necessary, but I can remember one or two runs when the fireman would not have refused to use it if one had been there! Coal over here seems to make a fearful lot of ash, and would probably clinker even more than it does if it were not that the stoker conveyor grinds it up fairly small. Sometimes tremendous lumps go into fire-boxes in England. During one of my trips there, the fireman was kept so keyed up that he simply did not have time to stop for anything, least of all to break up coal, and huge lumps went in that would only just pass through the fire-door.

A somewhat common entry crops up

in my notes at this point: "Ashcroft gauge (exhaust pressure) over-enthusiastic; registering several pounds with the throttle shut." It is an informative and useful device when working properly, but, like that noble animal, the horse, it does not always do so.

"No. 2832" was in first-class shape, having only been out of the shops a few weeks, and there were no knocks or pounds anywhere. Yet I find that after a triple stop at Elkhorn—for water, coal, and station—we left at 1.40, 20 min. late, I know not why. Speed became higher than ever, 75–80 m.p.h., and at Virden—we were in Manitoba now—where double track begins again, five minutes had been regained, and at Oak Lake, a few more. Here our "opposite number," the westbound "Dominion," passed, both trains doing about 75 m.p.h., bringing a blast of air into the cab far stronger than I remember was the case when "Flying Scotsmen" or "Coronation Scots" spurned each other at this speed. Their streamlining prevented much of the air disturbance caused by the "Dominions" tending to direct air currents upwards instead of sideways.

Clarke, too, did not like running behind time, and the speed was held at 75–80 m.p.h. as much as possible. One could sense the feeling of determined endeavour; the atmosphere in the cab was a synthesis of sound and fury. There was a ceaseless, harsh roar from the exhaust, merging with the muffled rumble of the wheels, the rush of air past the windows, the mournful wail of the whistle at crossings, and the occasional tolling of the bell in yard limits. At high speed the action of the engine was not quite diesel-electric—not to say that it ever had been—and there was considerable rolling on the straights. As a curve was entered there would be a sudden lurch, and possibly the hiss of air from the driver's brake valve—this meant a little moderation of pace was called for in the interests of safety. The slam of air from a passing train—the rattle of reverberating sound flung back from a long 100-car freight standing in a siding—the faintly heard ceaseless grinding of the conveyor screw, if you listened closely—all these sounds combined to make up the chorus inseparable from cab travel, part and parcel of the song of the locomotive. And it *is* a song—there is music in it—but you have to be in tune with a locomotive before you can hear it. It may be that you have to love a locomotive before you are permitted to hear it—in that case I evidently do, because I can.

Locomotive Driving

Many people have the most exaggerated ideas about the art of locomotive driving; I did myself, in fact, before practical experience in the cab took much of the gilt off the gingerbread. It is far more simple and straightforward than one would think, and I was given yet another demonstration of the truth of this, sitting in my "stuffed seat" in "No. 2832's" cab as the "Dominion" ran across the Manitoban plain. For long periods Clarke left the throttle and valve travel alone, and though, of course, both skill and judgment are sometimes needed to get the best out of a locomotive, it is not necessary to be a superman to do so, or to take a lifetime to acquire the ability. The control of a modern locomotive, at any rate so far as cylinder events are concerned, is a comparatively easy matter, and the juggling and fussing with throttle and reverse which the enthusiast apparently imagines to constitute the art of locomotive management, the jockeying, the coaxing, the finesse only possible to a master of craft with a lifetime of experience behind him—it is mostly moonshine, my masters, moonshine! It is not necessary, and does not take place. It certainly did not occur in the cab of "No. 2832"; the knotty problem of setting the positions of throttle and reverse wheel did not seem to furrow Clarke's brow with care, nor was his countenance "sicklied o'er with the pale cast of thought"! Like the majority of good enginemen, he merely set his controls in certain proved relative positions—say, two-thirds throttle and 25 per cent. cut-off, correct for a 950-ton load moving at 75 m.p.h.—and then left them alone as far as possible, only making such slight variations as were called for by changing gradients, and these occasions were not frequent. Sometimes a wider throttle or slightly lengthened valve travel would be necessary, due to gradient or falling speed—one or the other, seldom both. There was little evidence that exceptional skill or judgment was required to get all that was needed out of the engine.

To be able to make a reasoned decision as to the exact relative value of throttle and valve travel under every possible circumstance must be the mark of a locomotive driving virtuoso—a maestro! So far as my observations go, covering tens of thousands of miles in the cab, watching the methods of hundreds of experienced men at the throttle, I am still unable to be dogmatic as to which is of major importance. In fact, I am by no means sure that it matters "a hoot in hell," as the saying out here is! Whether an engine is "driven on the throttle or the valves" seems very largely a matter of individual preference on the part of the driver—the results appear to be much the same. I still hold to the view that I have tried to present in these articles more than once—that locomotive driving is not such a finicking, nerve-wracking task as the imaginative enthusiast would have us believe. And my observations in the cab of "No. 2832" only strengthened this opinion. If anybody should try and convince you that it is, quote Fireman Stones, of the "Mid-day Scot"—"Aw, skip it!" And now, having drifted into this subject of engine handling, I will ask permission to enlarge on it a little, and to use a striking British example to prove my point; it will serve quite well, driving methods on both sides of the Atlantic having much common ground. I would like to draw attention to this instance, as it really is tiresome to read the exaggerated nonsense in the lay and semi-lay Press about locomotive driving methods. The average engineman is neither a genius nor a wizard, and does not need to be to handle a modern locomotive, which is a simpler matter than the flighty journalist or awe-stricken "fan" would have it to be. The record of the following actual test run will prove this.

The other day it happened that I came across an article in a back number of an English publication devoted to railway matters; it dealt with the test run of "The Silver Jubilee" from King's Cross to Darlington, on August 27th, 1936, the engine being L.N.E.R. No. 2509, "Silver Link," "A4" class, handled by Driver Sparshatt, since retired. The account included full details of the speed, boiler and steam chest pressure, regulator opening and cut-off, at every important passing point, as recorded both in the cab and the dynamometer car; they bring out clearly how these were interconnected, and affected by gradients, curvature and restrictions, which, as many readers will know, are numerous and fairly severe over this route. These details are most interesting, and "give furiously to think"—of how very simple the handling of the engine really was. The run was an important test, and both men and machine were carefully chosen, "top link." Now, the imaginative enthusiast would probably picture Sparshatt juggling with the regulator and reverse from start to finish. All his lifelong accumulation of locomotive lore would be assumed to be brought to bear mile after mile, minute by minute—perhaps second by second!—on the problem of how to get the finest possible results from his engine by the sympathetic adjustment of interacting controls. In perfect harmony with his engine, Sparshatt is pictured as coaxing response from it, his every sense concentrated upon gauges and controls, each change in gradient demanding and being conceded corresponding variations of throttle and reverse. It makes one positively tense to think of it—hands, brain, and machine together must have constituted a miracle of co-ordinated effort, only to be attained by lifelong experience and consummate craftsmanship. Sparshatt should have been crowned with laurel at the finish! But, alas, this is but a fanciful picture. In fact, it is not a picture at all—it is a cartoon, a caricature—nothing of the sort took place in the cab of "Silver Link" on August 27th, 1936, and the official figures show it. They record that the engine pulled out of King's Cross with full-open regulator and 65 per cent. cut-off, the latter being shortened progressively in the usual way as the speed increased up the 12 miles' Potters Bar bank, to 18 per cent. as the engine passed over the crest. From this point on, with but one instance of increased travel following a momentarily shut regulator due to a severe speed restriction through Peterborough, *the cut-off remained absolutely unaltered at* 18 *per cent., right to the* 173*-mile post*! Farther along, at two other points, the cut-off was again lengthened for the same reason, but apart from these three instances it remained 18 per cent., up hill and down dale, from Potters Bar to Darlington, 219 miles. As for the regulator, it was generally full open and left so, as far as possible. When "Silver Link" went too fast Sparshatt closed it a little; a severe speed restriction meant its shutting, and reopening afterwards; brakes were sometimes applied before a curve. Really, I can see nothing very striking about such a run; it seems to me to call for no exceptional skill on the part of the driver, or power output on the part of the machine. It may be looked upon as the locomotive equivalent of a motorist driving a powerful "top-gear" car at high speed over a good road, using nothing but steering wheel, throttle and brake to do so. Anyone could do it; it is quite simple. The speed on this "Silver Link" run was nothing out of the ordinary; it was almost entirely in the 70s and 80s, with but three brief "peaks" of 90 or slightly over, all attained at the bottom of falling gradients, where they could be expected. It was clearly a test run with a 90-mile limit, which was kept admirably throughout.

All through the article one gathers the impression of an attempt to create an artificial atmosphere of stress and strain—of glamour, if I may use that overworked Hollywood word! It exaggerates; it tries to make the run something out of the ordinary, involving driving of exceptional brilliance—this, by the way, is referred to as "masterly." Wherein? Any L.N.E.R. express driver could have done it, probably. Quoting: "The cut-off . . . dropping to 25 per cent. nearing Werrington Junction, which produced an *electrifying accleration* (my italics) from 23½ m.h.p. to 75 m.p.h. in no more than 3 miles"—the writer omitting to explain that these 3 miles are mostly level and downhill at 1 in 330, and that the "electrifying" 75 was reached just beyond the foot of the descent. I can see nothing

"electrifying" in a powerful "A4" loaded with a paltry 270 tons accelerating from 23½ to 75 in 3 miles of level and down; if it could not, there must be something the matter with it! No, it is overdone—artificial—high-pressure journalism! I do not like this in connection with locomotives, because it misleads.

Fortunately, in the same publication, I have chanced upon a French example of acceleration, one which makes a striking comparison with "Silver Link's" little effort. A Paris-Orleans compound "Pacific," hauling 225 tons, a train of very similar weight to the "Silver Jubilee," covered 9 miles in 9 min., *from a standing start*, during which it accelerated *up* 1 *in* 500 from 25 to 56 m.p.h. *in one mile*. Later in the same run, this engine climbed 9 miles of 1 in 200–250 at a minimum speed of 74½. These are the sort of performances worth drawing attention to; they no doubt called for skilful engine handling, which I should have liked to watch, all the more as these compounds have, I believe, individually operated valve gear for high and low-pressure cylinders. "Silver Link's" run, and the engine manipulation involved, appear to have been quite matter-of-fact, and this is generally the case with most accounts of locomotive performances one reads; in spite of the "writing-up" they get, they are largely much ado about nothing.

I must not fail to say, however, that in all this I am not in any way attempting to depreciate Sparshatt or "Silver Link"; both did all they were called upon to do on this occasion—which was evidently nothing very much! I am sure they would agree that the run was nothing to make a song about. My thoughts go back to "gallant little 'Cheltenham,'" with its trembling body and furious soul, pulling and tugging away at its 440-ton load up the weary climb to Litchfield, and my heart goes out to it" (THE ENGINEER, April 28th, 1939). It still does! *That* is what I call really fine locomotive work.

FROM BRANDON

Now to return to the "Dominion," merely repeating that the handling of "No. 2832" was as simple as "Silver Link's." The twenty superfluous minutes had all been made up by the time Brandon was reached at 2.50 p.m.; this is another divisional point. The 131 miles from Broadview, with eight intermediate stops (counting Elkhorn as three) had taken 180 min., 43·7 m.p.h. We left at 3.10, with Enginemen Rowden and Lower, in a drizzle, which induced a little slipping. Brandon sticks in my memory for two reasons: (1) It is in the midst of rolling country, the Assiniboine River watering it, and there are trees growing here and there, a blessed relief after hundreds of miles of scorched earth—the war insists on intruding; and (2) there is a road bridge across the track just east of the station; unless my memory is at fault, this is the only bridge crossing the line from the Rockies to beyond Winnipeg, a mere 1000 miles or so! I doubt if there are a dozen under it either, all replacing level crossings in city limits. Of tunnels there is not one between the Field Spirals and Kenora, again more than a thousand miles. A decided contrast to Britain! There are hundreds of level crossings, of course, nearly all ungated. Nearing Portage la Prairie—set in the dead level "Portage plains"—the C.N.R. main line comes in sight, converging on the C.P.R., and then crossing it, carrying on to a separate station in Portage. The last time the two companies' lines had crossed was in the Thompson Canyon, 1200 miles back in B.C., the C.N. then diverging north to come through the Rockies by the Yellowhead Pass, and only re-crossing its rival here in Manitoba. The two rival Transcontinental trains converged here, too, the seventeen-car "Continental" coming along, overhauling us—we were checked by signal to let it clear the crossing first—and going ahead of us into the town. Both trains had left Vancouver about forty-eight hours before, and were *en route* to Montreal, 1500 miles farther on. Canada is a big country.

The weather deteriorated at Portage, becoming raw, shivery, and blowing strongly, a complete contrast to the 100 in the shade at Saskatoon two days before. Window wipers would have been welcome; as soon as the drizzle came on the fireman's window faded out, becoming useless, the wind being on the port bow. These vestibule cabs are very comfortable in bad weather; with shut windows rude Boreas howls outside in vain, and roof ventilators prevent excess heat. The controls are so well arranged that the crew seldom have to get up to reach anything, doing most things from the deeply padded seats. "No. 2832" was in excellent shape, and all the motion imperceptible, which is not always the case, by any means. My notes say: "At high-speed riding very satisfactory, but L.N.E.R. 'No. 4793' still at top of class—no engine has ever come up to her—and never will—you can't improve on perfection. No nosing; quick lurches, and some rolling, due to track." Approaching Winnipeg, speed came down to 15 m.p.h. for several miles of track relaying, making our arrival in the Manitoban capital five minutes late, 6.05 p.m. The 357 miles from Regina, with fifteen stops totalling about an hour, had been covered in 572 min., rather over 37 m.p.h. The running average, with no allowances made for slowing and regaining speed, was 42 m.p.h.

(To be continued)

Fen Flood Protection

No. II—*(Continued from page 219, September 11th)*

I WILL now endeavour to explain the scheme. It is, as I have said, that for which we are now preparing the necessary plans. The main item in it is the relief channel running along the side of the Tidal River from Denver to just beyond the village of Wiggenhall St. Germans, where it will discharge into the Tidal River. There will be a sluice there which will exclude the tide, and the silt which the tide carries, and there will also be a sluice at the head of the channel near Denver, where it takes off from the Ten Mile River. This sluice will normally be kept shut and the water from the Ten Mile will pass through the existing Denver sluice into the Tidal River. During floods, however, it will be open and the water allowed to flow down the relief channel. In floods the Tidal River at low water flows at a very steep water slope, about 1ft. a mile between Denver and St. Germans, and this results in the high level of 110ft. in the Tidal River at Denver. This high level partly blocks the discharge from the Ten Mile and causes the water to rise in it to as high as 112ft. 6in., as occurred at the peak of the 1937 flood. The relief channel will be designed, however, to run at a much flatter water slope, namely, 6in. a mile at low tide, and consequently in a maximum flood 25 per cent. greater even than the 1937 flood, the water in the Ten Mile at Denver will only vary between 105ft. and 108ft., compared with 110ft. and 112ft. 6in. which occurred in the flood of 1937—see Fig. 2. At times we have been asked if it will work properly. It is certain to do so. It is only a matter of water flowing downhill.

As I have said previously, the sluice at the tail of the relief channel near Wiggenhall St. Germans will be shut during high tide and at this period the water coming down the channel from Denver will be stored in the channel itself, and in the proposed Stoke Ferry Fen Washlands or reservoir. These two reservoirs will keep the water level down to a maximum of 108ft., and will save the large pumping station which was proposed by Sir Alexander Gibb and Partners. The Stoke Ferry Fen Washlands will only be flooded about one year in three, and it will probably be possible for them to continue to be arable, if the Catchment Board, to whom they will belong, is ready to take the risk of paying compensation for the crops whenever an abnormally high flood occurs. The reservoir is shown near Denver, but we are now studying an alternative site quite near in the Fordham Fen, which will probably be found more economical.

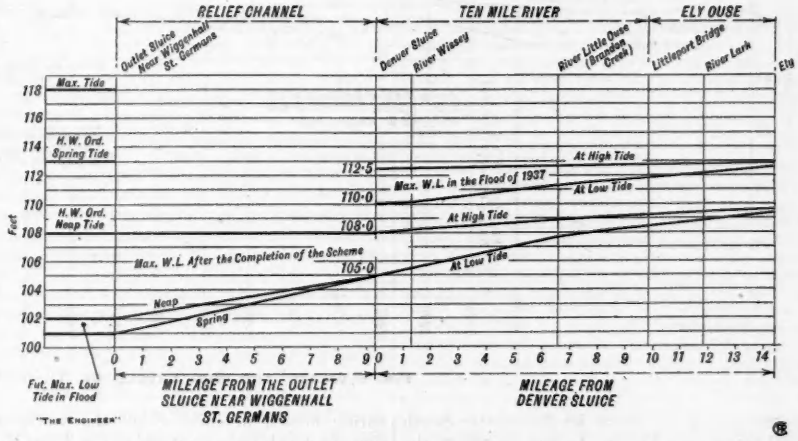


FIG. 2—RELIEF CHANNEL AND TEN MILE—LONGITUDINAL SECTION

I would emphasise that this is not a flood reservoir, but only a place to store water during high tide. Those of you who are members of the Catchment Board will have heard Colonel Tebbutt frequently object to flood reservoirs. We are entirely in agreement with him. The difficulty with such reservoirs is that they may get filled at the beginning of a flood, and there is then nowhere for the future flood water to be stored—for example, the Washlands in 1937. This reservoir is, however, not a flood reservoir, but simply one to store the water when the tidal gates are closed at the outfall sluice. It will be emptied every tide down to a water level of 105ft. The practice of storing water during high tide is well known in the Fens.

There is an exactly similar reservoir at the Stow Bardolph pump on the Tidal River, where there is a small balancing reservoir of about 5 acres. The principle, however, is exactly the same as in the proposed Stoke Ferry Fen reservoir.

FIG. 3—AVERAGE CROSS SECTION OF RELIEF CHANNEL

You will see therefore that we intend to produce quite low water levels, varying from 105ft. to 108ft. in the Ten Mile River at Denver, but we are then up against the difficulty of producing a lower water level than occurs in present floods, say, near Ely, where there was a maximum level of 112ft. 9in. in the flood of 1937. In order to produce an effective lowering of the water level at Ely, it is necessary to widen and deepen the Ten Mile River and the Ely Ouse, and this is included in the estimate. As you will see from Fig. 2, the maximum water levels at Ely will be reduced to 109ft. 6in.—that is, 3ft. 3in. lower than in the flood of 1937.

Fig. 3 shows an average cross section of the relief channel. It is about the same size as the Tidal River. Fig. 4 gives a typical cross section of the Ten Mile River, showing the proposed enlargement. There has been a lot of talk about silting of the bed of the Tidal River, between Denver and the sea, and the effect of this silting on flood levels in the South Level rivers—see Fig. 5. In fact, however, the silting which has occurred has really had no effect at all on the flood water level at Denver. It is true that the bed of the river between St. Germans and the sea has silted and risen several feet on the average since 1915. Fig. 6 gives a cross section of the Marsh Cut showing what happened between 1868 and 1937. The river bed has not silted permanently between Denver and St. Germans. There is some silting here during dry periods, but it is washed out when a flood occurs. What may be called the permanent silting is all below St. Germans. This has affected the water levels during periods when there has been very little water flowing in the river, both at Free Bridge and at Denver. There seems to be a fairly general opinion that if only the bed of the Tidal River could be restored to the position in which it was in Mr. Wheeler's time, it would greatly improve the conditions as regards flood protection. I do not quite know why this opinion should be held, because Mr. Wheeler was asked to report because of the danger of flooding. It is true that when he wrote his report in 1884 the Tidal River was clear of silt, and this is confirmed by Fig. 5. Denver is the crucial point, but as you will see from the diagram, quite as great floods occurred about that time and produced as high water levels at low tide at Denver as in the recent great floods of 1937, 1939, and 1940. The records are not quite complete before 1860, but from those which we have we know that high floods up to about 110ft. occurred at Denver in 1824, 1828, and 1852. Therefore, it is clear that the condition of the Tidal River has not affected the water levels at Denver during floods, in spite of all the works and changes which have occurred in the Tidal River since the beginning of the nineteenth century. Denver, in fact, is too far away from the sea for the bed in the lower reaches of the river to have any effect on the water levels there in floods.

Fig. 7 gives an interesting diagram produced by our chief assistant engineer, Mr. C. B. Case. It evolved from our study of the proposed Free Bridge barrage. It shows that it would be possible to leave out Mr. Kraaijeveld's enlargement of the river between Free Bridge and the sea, and still produce almost identically the same water level at low tide in flood in the Tidal River at Denver. This, by calculation, confirms what I have already explained occurred in Nature when the lower part of the river silted.

It has been argued that the abstraction of flood water by the relief channel will cause silting of the Tidal River between Denver and St. Germans, and that this will raise the water level in the Tidal River at Denver and adversely affect the discharge from the Washlands. A somewhat similar, though greater, abstraction of water occurred when the Middle Level moved their outfall from Denver to the Tongs Drain near Stow Bardolph, and in 1848 dug their main drain down to St. Germans. This involved extracting something like 4000 million cubic feet of water per annum from the Tidal River between Denver and Wiggenhall St. Germans, but, as you will see from Fig. 5, this had no effect, even on low tide levels at Denver during the summer with very little river water, and, of course, not on low tide levels there during floods. The relief channel will only flow for about ten days during very high floods, and we estimate that the average amount of water which will be sent down it per annum will be in the region of 1000 million cubic feet, or only about one-quarter of the amount of water which was prevented flowing down when the Middle Level Commissioners moved their outlet to

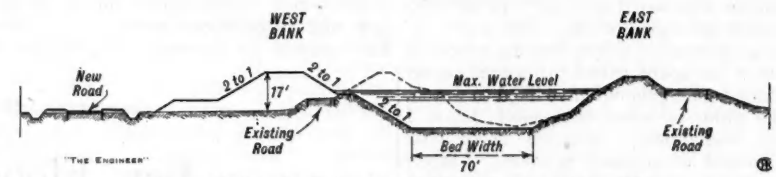


FIG. 4—CROSS SECTION OF ENLARGED TEN MILE RIVER

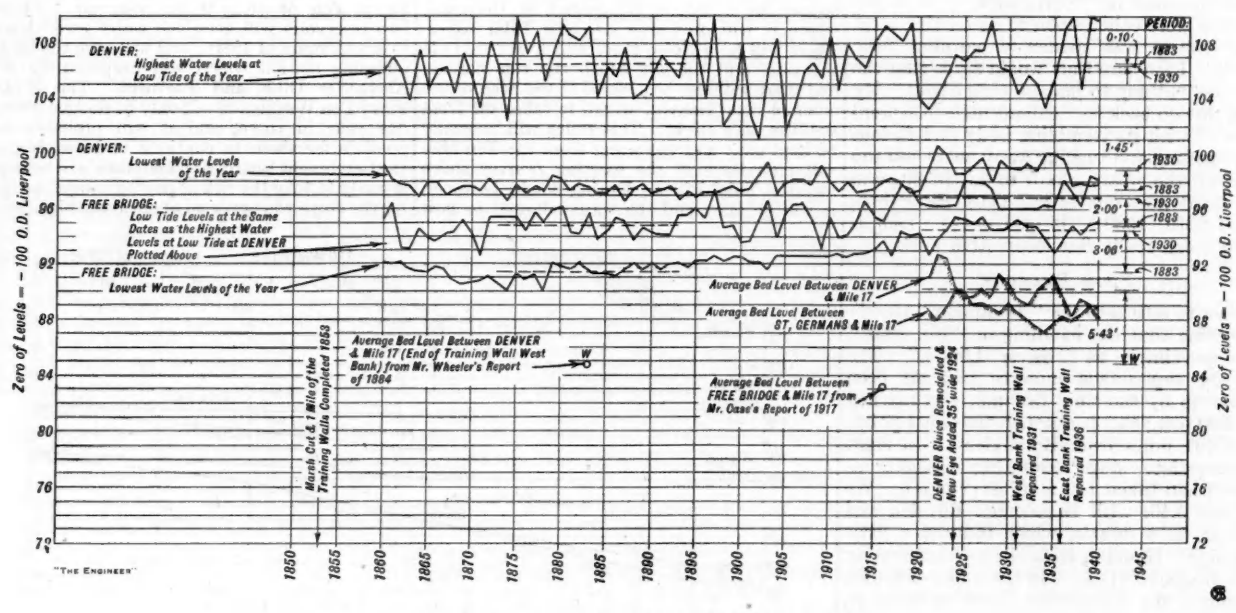

Zero of Levels = – 100 O.D. Liverpool
DENVER: Highest Water Levels at Low Tide of the Year
DENVER: Lowest Water Levels of the Year
FREE BRIDGE: Low Tide Levels at the Same Dates as the Highest Water Levels at Low Tide at DENVER Plotted Above
FREE BRIDGE: Lowest Water Levels of the Year
Average Bed Level Between DENVER & Mile 17 (End of Training Wall West Bank) from Mr. Wheeler's Report of 1884
Marsh Cut & 1 Mile of the Training Walls Completed 1853
Average Bed Level Between DENVER & Mile 17
Average Bed Level Between ST. GERMANS & Mile 17
Average Bed Level Between FREE BRIDGE & Mile 17 from Mr. Case's Report of 1917
DENVER Sluice Remodelled & New Eye Added 35' wide 1924
West Bank Training Wall Repaired 1931
East Bank Training Wall Repaired 1936
PERIOD:
0·10'
1883
1930
1·45'
2·00'
3·06'
5·43'
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FIG. 5—WATER AND BED LEVELS OF TIDAL RIVER

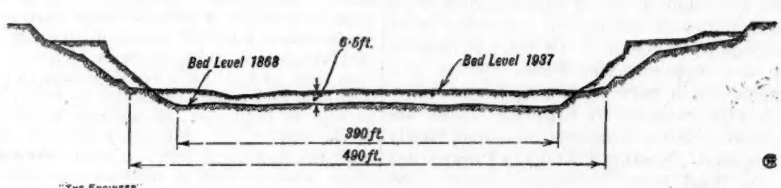

FIG. 6—CROSS SECTION OF MARSH CUT

St. Germans. The bed of the Tidal River, as you will see, has had some effect at Free Bridge, near the outlet of the proposed relief channel at Wiggenhall St. Germans, but the flood protection scheme has been designed to work satisfactorily and deal with even greater floods than those which occurred in 1928, 1937, 1939, and 1940, with the bed of the river at the level at which it is now, after this silting had taken place.

I will go on now to explain the proposed Magdalen Bend Cut and barrage, which was proposed by Mr. Griffith. This is very clearly a bend in the river which should be removed, and there has been talk of doing so for very many years. It is, in fact, the only bend there now is. If it is removed, it provides the opportunity of building a barrage cheaply in the dry. This barrage will have two functions :—

(1) During very high tides its sluice gates can be closed when the tide approaches a dangerous water level and the tidal water prevented from flowing upstream. This is a very great safeguard, and, in our opinion, the barrage is worth building for that reason alone. A serious breach occurred in the South Level Barrier Bank in 1938. This would have been prevented from happening if the barrage had been in existence then. It is true that instead

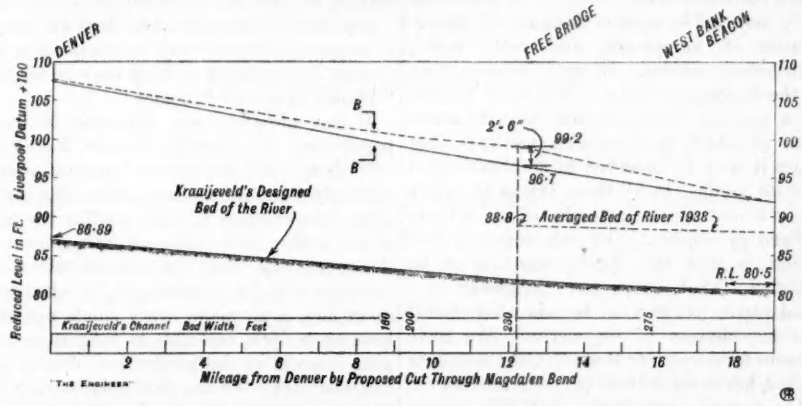

FIG. 7—KRAAIJEVELD'S SCHEME WITH NO WORK BELOW FREE BRIDGE

of the barrage the Tidal River embankments can be heightened and strengthened where necessary, but there is always the danger of something like a rat hole, and a serious breach taking place. Of course, the barrage will be made of concrete, and there is no danger of anything happening to it. We know that there is a very good clay foundation.

(2) The barrage also has a second function, that of scouring the bed of the river. It should be clearly understood that it will not be closed during floods. It will be completely open then, and scouring by means of the tidal water would only be done at times when there is very little river water passing. The method which Mr. Griffith proposed was that at high tide the barrage gates would be closed, and the tidal water retained for three or four hours upstream of it. The sluice gates would then be released quickly, and a steep water slope produced both upstream and downstream of the barrage. This would have a scouring effect on the silt in the bed of the river. The model experiments have demonstrated this, and, in fact, show that the bed could be lowered by about 1ft. on the average. Models are very useful, but they have their limitations, and it is not absolutely certain that exactly these effects would be produced in Nature. Also, as I have already explained, the exact level of the bed of the river has no effect on flood water levels at Denver and therefore we do not attach much importance to its scouring effects.

WAR AND THE GAUGE INDUSTRY.—It has recently been estimated that eighty-five machine shops in Canada are now engaged in manufacturing the 25,000 types of gauges required for the production of the munitions used in modern mechanised warfare. Expanded from a group of five shops in 1939, this essential industry is expected this year to double the number of basic items being produced.

Sponge Iron*

"A SPONGE iron plant at every mine opening ;" thousands of tons of sponge iron flowing from these plants into battleships, tanks, and guns ; additional iron enough to make up for our shortage of scrap and pig iron, and thus win the war. That is the vision seen by the eminent Ickes of the Interior and now being presented to Congress. What an entrancing vision.

This picture has considerable background. Sponge iron is not new. For more than half a century, engineers in this country and abroad have pursued this attractive will-o'-the'-wisp. For years *The Iron Age* has advised would-be investors to steer clear of numerous stock promotion schemes involving the low-temperature iron ore reduction process. How many millions of dollars we have saved the innocent by this advice we shall never know.

The best minds of our steel industry have worked on this problem, and millions of dollars have been invested in trying to solve it. And now Secretary Ickes has secured an appropriation of 600,000 dollars which he believes will do the trick.

It is true that Sweden produces some sponge iron. But very little compared with her total iron and steel production. And Swedish ore is a high-grade ore, not to be compared with the low-grade ores to which this process would be applied in this country.

Germany has low-grade ores. And Germany is the mother of "ersatz." For twenty years Germany has been pursuing sponge iron with the result that to-day she has a metallurgical hang-over and two defunct pilot plants. And when the great Goëring Works was built, the sponge iron process was conspicuous by its absence.

The United States Steel Corporation has also pursued sponge iron, spending over 1,500,000 dollars in so doing. And here is what the Corporation says about it in the authoritative work, "The Making, Shaping, and Treating of Steel," by C. B. Francis, of Carnegie, Illinois.

"From 1850 and up to the present time much money has been spent in vain attempts to develop a direct process which would be practical. . . . As practically all of these processes have been abandoned, it is deemed unprofitable to include details of them here. . . ."

Sponge iron as produced, unlike pig iron or scrap, is full of impurities. This necessitates additional refining operations in open-hearth or electric furnaces, all available evidence indicating the need for at least one additional run off of slag in each case. You can imagine how that would slow down the capacity of our existing equipment.

Mr. Ickes estimates that his 600,000 dollars will build two plants, each giving 30 to 50 tons per day. Taking the average of 40 tons, this means an investment of 7500 dollars per ton of daily sponge iron capacity. You can build blast-furnaces that will make real pig iron at a cost of 4200 dollars per ton of daily capacity. And we know they will work.

* *Iron Age*, July 23rd, 1942.

Let Mr. Ickes play with his 600,000 dollars. If he can do with that what others have spent millions trying unsuccessfully to do, we will take our hats off to him. But until he makes good, let us not throw dollars, hours, and tons of material down a knothole in search of imaginary dimes.

Economy in the Use of Non-Ferrous Metals

THE following statement has been prepared by the Non-Ferrous Metals Control and issued by the British Standards Institution on behalf of the Control :—The enormously increased demand for non-ferrous metals for war purposes and the restriction of supplies make it necessary for the most stringent economies to be effected in their use. It is no longer possible to maintain peacetime standards of perfection and it is the duty of all to ensure that the quality of the material employed is never higher than is absolutely necessary. The need for economy applies to all non-ferrous metals, including those most commonly used in cast copper alloys, such as tin. Approximately one-third of all the tin used in this country goes into copper alloys. It is essential, therefore, that tin-bearing alloys should never be used if a tin-free material can be employed, and that, where this is not possible, the tin content should be reduced to a minimum. To assist users to meet this urgent need, a new range of standards for copper alloy ingots and castings, Nos. 1021–8—1942, has been prepared and issued by the British Standards Institution at the request of the Non-Ferrous Metals Control. Attention is drawn to these standards, which immediately supersede certain existing standards. The following general considerations should be borne in mind :—(*a*) Never use a non-ferrous metal or alloy unless it is certain that there is no substitute available which is in more plentiful supply ; (*b*) where a non-ferrous material is necessary, use the least possible weight of the lowest possible grade ; (*c*) make sure that all scrap is kept clean and free from contamination, use the highest possible proportion of scrap, but never of a higher grade than is absolutely necessary ; (*d*) do not hoard your scrap; if you cannot use it for approved purposes, sell it and put it back into circulation ; (*e*) if you are accumulating in your works residues such as skimmings, casters' ashes, sweepings, &c., and cannot re-use them in your own products, the Control will advise you where this material can most usefully be directed. With particular reference to British Standard alloys, the following points are of importance :—(1) Practically all requirements for cast gun-metals and brasses can be met from the following alloys :—For very special applications, 88/10/2 (B.S. 382–3), 88/8/4 (B.S. 1021–2) ; for high-grade work, 86/7/5/2 (B.S. 1023–4) ; for general work, but only where a tin-bearing alloy is essential, 85/5/5/5 (B.S. 897–8) ; for general work in place of tin-bearing alloys, type A brass (B.S. 1035–6) ; for all work where a copper alloy is not required to have any special properties, type B brass (B.S. 1027–8). (2) The most efficient use of scrap is essential. On no account should the grade of scrap used be of higher quality than that of the alloy in which it is to be incorporated, unless to counterbalance the use of a still lower grade of material. (3) When sufficient supplies of scrap are not available to meet demands, virgin material must be provided. As far as possible, it must be used only in the highest grades of alloy (*e.g.*, B.S. 382–3, B.S. 1021–2, or 2 B 8 phosphor bronze). Virgin metal or material of comparable quality should preferably be employed in castings of alloys made direct in one melting stage. This releases ingot-making capacity for the production of lower-grade alloys from mixed or other scrap of an indefinite composition which requires to be melted in bulk under properly controlled conditions. (4) B.S. 1025–6, type A, casting brass, has been designed to take care of the lower grades of scrap unsuitable for the better qualities of wrought products. The aluminium content has been kept low to ensure a good casting material. Elements other than copper and zinc are impurities and are allowed up to the limits stated only to cover such quantities as may be present as impurities in the scrap from which the brass is produced. (5) B.S. 1027–8, type B brass, has been designed to take care of the lowest grades of scrap only ; principally material more highly contaminated with aluminium, which is allowed as an impurity up to 0·25 per cent. Allowable elements other than copper and zinc are impurities only and must never be added intentionally. If proper care is taken to avoid the contamination and mixing of scrap and swarf the quantity of material available for use in type B brass should be greatly reduced.

The Engineer

SEPTEMBER 18, 1942

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CHANGES OF ADDRESS

*** *Will Subscribers please note that in all advices regarding changes of address it is necessary to have both old and new address, as our lists are kept alphabetically by towns. Advices of this nature should reach us by the first post Wednesday morning prior to the alteration.*

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INDIVIDUALISM IN THE FACTORY

IT is the normal practice of manufacturers to follow their own bent. Their products are stamped with their own personality. It is as easy to distinguish between them as between a Constable and a Gainsborough. The drawing-office leaves its marks on designs and the manager's sign manual can be seen in the manner of executing them. This is all to the good. In mechanical engineering it is rare to find only one best way of doing things. As a rule there are several, between the merits of which it is difficult to distinguish. One has to beware of hasty judgment. Of two products one may appear to be more economical to produce than the other. Yet when all the circumstances are known there may not be a pennyworth of essential difference. Once a method has been fully developed, the equipment perfected, and the operatives trained, it may be quite able to compete with a newer and apparently better method.

It might be thought that in the production of war materials none of this would be true; that it would be possible to specify one best method and to insist upon its adoption by all. No doubt the "planners" hold that view. But the responsible Ministries have been wiser in their generation. They know that there is wisdom in multiplicity of counsel and, leaving liberty within the specification, they keep the door open for individual improvements. Thus one may find in works all over the country that the same end is being reached in different ways. It is particularly noticeable in the design and manufacture of aeroplanes, and with highly satisfactory results. It may be seen, too, in the making of tanks. That work is done by a number of independent private firms, each of which uses its own methods. Or again it may be observed in shipbuilding in private yards. In all these things there are no cut and dried methods which all are obliged to employ. The only common condition is that the specifications must be satisfied. That, as we have suggested, is a good plan; yet it must be admitted that it has the defects of its merits. We have reasons for suspecting that all works managers do not know what their opposite numbers in other factories are doing, and still greater reason for suspecting that not one of them would willingly adopt the methods of another. Very few people like being set right by someone else. They regard it as a reflection on their own ability. Willing as they may be to accept ideas from a neutral source, they are reluctant to do so from a known individual and particularly a business competitor. That is where the technical Press and technical publications of various kinds played in times of peace an important part. They distributed knowledge in a more or less impersonal way. The fear of spreading information which might be serviceable to the enemy has put an end to that service. Neither in the Press nor on the public platform is the circulation of information about specific up-to-date methods encouraged, save in very general terms. There is, as far as we are aware, no forum at which managers can discuss difficulties and methods. It is possible that the Regional Boards may accomplish something in this way, but we have no information to that effect.

It is conceivable that had a strong board of mechanical engineers been set up in the early months of the war, it might have acted as a co-ordinating body and as a clearing house for information on methods and processes. It might, moreover, have done what the individual adviser finds it very difficult to do. Managers might bow to the decisions of a Board, even accept them gladly, whilst they would resent instruction from an individual competitor. That is a psychological difficulty which a purely impersonal organisation might overcome. Dare we hope—now that a first-rate mechanical engineer has been appointed to advise the Minister of Production—that such problems as we have broadly indicated will receive attention?

Works Relations Schemes

SOME weeks ago we stressed the importance of suitable propaganda in the factory, and the opportunity was taken to suggest that the wholesale use of slogans had inherent defects. We notice with satisfaction that similar sentiments are finding their way into the American technical papers, one of which, bravely borrowing a weapon from the enemy, exclaims, "Don't slug 'em with slogans." We are not surprised to be informed that "any intelligent worker will and should resent" such sentiments plastered over the workshop walls as "Work Wins War," "Count Me in this War," "Shake a Leg, Mister," while "Do Your Duty" "conveys the implication that the boss is doing his, but that you are not doing yours." Slogans may be an easy way of making an appeal, but it is a way far from the best. It is our desire to suggest the better way, which lies in a far greater development of what may be termed "Works Relations Schemes."

It has already been indicated in these pages that the Royal Ordnance Factories, with their Joint Productive Consultative and Advisory Committees, have taken the somewhat revolutionary line of enlisting the help of the worker in the efficient management of the workshop, but the subject of works relations is a far broader one, in which the main idea is to make every single operator keen on his job, and able to take an intelligent interest in the production of even the simplest part. We are glad to know that the Ministry of Supply considers this question as of sufficient importance to warrant the setting up of a special Public Relations Branch, which maintains contact through the various production departments with a large number of factories working for the Ministry. The staff in this special branch is composed of men who have both factory and newspaper experience, and who are able to spread good ideas and readily sense special needs in relation to observed *morale*. The idea of compulsion is repugnant to the scheme, for co-operation and understanding make its keynote. Many methods have been suggested and explored, and allusion has been made to them in other articles on this page, so that we only propose to instance a few that seem worthy of further development. Perhaps the most important step is that of ensuring that the worker knows the purpose for which the article he or she is producing day in and day out is intended; it all seems so remote from the war effort as to be meaningless. If a picture is displayed clearly showing how the particular component fits into some article, and how that article in turn is assembled into something bigger, something that perchance figures in the daily Press, then interest is awakened. That small piece becomes more vital when it is shown, let us say, set in the fuse, which fuse is then depicted in the shell destined to bring to destruction an enemy aircraft. It is still better when the bomber pilot, fresh back from some notable feat, calls at the filling factory and talks to the employees who are engaged on filling his bombs, when one

of our paratroops has a talk with the people who make his equipment, or when the A.A. gunner tells the men in the gun factory something of his life and the behaviour of his weapon. Such visits are being arranged daily, and all that the factory management has to do is to provide transport for the speaker from the nearest railway station to the works, and as these talks usually take place in the midday interval at the works canteen, he will generally be entertained to luncheon with the workers, and after his talk be taken back to his train. We understand that in the first six months of organising these talks the Ministry of Supply has provided over five hundred speakers from the Services for different factories, and the results have been strikingly successful. The visits arranged to the proof butts for workers to see their products actually tested, for girls from filling factories to visit Bomber Command stations and talk to crews returning from action, for inter-factory visits so that persons working on sub-contracts may see how a job that is remote from the finished product will take its place in the final stages of production—all these have added a spur to production.

The general principle underlying efficient works relations schemes must always be information rather than exhortation, and to this end no tool will be despised, be it the educational film—and incidentally the Ministry of Supply makes a large number of its own technical films for showing in factories for training recruits—be it the factory radio, with its great potentialities, or be it the use of the public Press, in fact, anything that will encourage a better appreciation of the industrial front. To sum up the position, every effort is made to give workpeople a clearer perspective, enabling them to appreciate what happens as a result of their personal efforts. It has been abundantly proved that men and women in our factories are extraordinarily receptive of information, and welcome demonstrations, while mere exhortations leave them cold or even sullen. The more manufacturers realise the value of works relations schemes, the greater will be the effect on output. Much has been done, but much more still remains to be done.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

EDUCATION AND THE WAR EFFORT

SIR,—I think Mr. Watson must have overlooked the experience of the 1914–18 war or he would not attribute the Army's deficiencies to the controlling politicians.

Four important new instruments of warfare appeared during this period, the aeroplane, the tank, the Stokes trench mortar, and the Mills hand grenade. All of these were entirely developed by civilians, and the three latter had to be forced upon the Army authorities before they were put into use. The tank was never effectively used even at the end of the war, and no tactics were developed either then or up to the present war, such as the Germans sprung on the world in the invasions of Poland and France.

On the other hand, the Navy adopted and developed the water-tube boiler and the steam turbine for propulsion well in advance of civilian experience. The high-power I.C. engine with mechanical injection was in use in submarines long before it came into use on land, and such novelties as the paravane for mine sweeping and the listening devices for the detection of submarines were instantly taken up without requiring outside pressure to get them adopted.

This difference between the two Forces is, I think, accounted for by the fact that for a long period both the executive and engineering branches of the Navy received a joint training, which included theoretical and practical engineering subjects, while in the Army the engineering side was almost entirely neglected and considered an inferior section, as is shown by the limit put to the rank which can be attained.

The attitude of an engineer is always towards the attainment of the greatest efficiency, whether it is in design or organisation. This calls for a receptivity towards new ideas and methods which does not appertain in any other walk of life. No engineering concern could exist for long which did not keep this point of view.

If Mr. Watson's contention as to the politicians being responsible is correct, is it not a fact that they are nearly all victims of the highly conventionalised and conservative so-called education in force at our public schools? Can anyone imagine a Cabinet of engineers being responsible for the blind policy pursued by this country between the two wars?

It seems to me the evidence Mr. Watson puts forward torpedoes his own case.

I notice Mr. Watson misses Latin and mathematics from his "liberal" education, but what education can be called liberal which omits astronomy, physics, and geology teaching us about the world on which we live and its position in the universe; which does not include something of agriculture, on which we depend for our very lives; which leaves out engineering and chemistry, on which the whole of modern civilisation is founded? "Liberal" indeed—it is a travesty of the word.

The control of education seems to have got into the hands of a most reactionary set, without an atom of the modern outlook. What is needed is an entirely new point of view. A view as a new problem is regarded by an engineer solely with the idea of obtaining the most efficient result in the training of the mental faculties and the acquirement of what useful knowledge is possible in the time available.

F. O. L. CHORLTON.

Bury, September 14th.

SIR,—Mr. R. G. Griffiths' letter in your issue of 4th inst. is in effect another way of asking the fundamental question of moral philosophy: "What is the good of anyfink?" I agree with him that the answer is "Nuffink."

I must, however, challenge his assertion that if my associates and I get a man from London to New York in a few hours we should not be able "to show him what to do with himself when he gets there."

A very wise man once said about a much smaller and less interesting London than the one of to-day that a man who is tired of London is tired of life. It would therefore seem to us that if Mr. Griffiths' hypothetical traveller were found on arrival in New York not to have had his imagination stimulated by our achievement and not to be grateful to us for the additional mental and material opportunities we had placed within his reach, he would be for all practical purposes a dead corpse and we would invite him to step over to the nearest cemetery and have himself buried.

My letter suggesting the formation of a British Engineering Association has had the happy result of introducing me to "The Engineers' Guild," an organisation apparently very much on the lines of the one I had in mind and one which, I find, you have already favourably commended to the notice of all fully qualified engineers.

I hope shortly to meet the Council and to have the opportunity to offer them part of my leisure, experience, and imagination, bearing in mind that the principal difficulties liable to mar the usefulness of such associations arise from the large number of people wishing to open their account with an overdraft.

F. L. MAYER, B.Sc.

Kingston-on-Thames,
September 12th.

SOME GRASSHOPPER ENGINES

SIR,—Since my article appeared on the above I think many readers, especially a number who were kind enough to write to me personally on this interesting subject, will be interested to know that a month ago I was able to arrange for the fine set of Grasshoppers at Beccles to be preserved in the Bridewell Museum, Norwich, instead of going to the scrap heap. They have been given on permanent loan by the Corporation of Beccles, but for obvious reasons will not be erected until after hostilities.

I should be interested to hear if another pair is preserved elsewhere, as to the best of my knowledge Norwich is the first museum to accommodate such an interesting example of early steam engineering.

RONALD H. CLARK, A.M.I. Mech. E.

Norwich, September 12th.

HISTORIC ACCIDENTS AND DISASTERS.—THE "PRINCESS ALICE"

SIR,—Referring to the above article in your current issue, there is no doubt that in the main your contentions are correct, in particular regarding the weakness of the paddle steamer's structure. I would, however, like to ask what would have happened in similar circumstances to the "Crested Eagle" or the "Royal Eagle." Would they not have both foundered, probably within a few minutes? I always understood that the captain of the "Bywell Castle," at the moment of impact, had already reversed his engines and was therefore unable to keep his bows in the gap made in the paddle steamer's starboard side; in fact, the collier had actually commenced going astern at this critical moment. Furthermore, Captain Grinstead of the "Princess Alice," so far from wishing to delay his journey (for the reason you mention, viz., to dispose of his liquid refreshments), was actually endeavouring to make up for lost time, and that was his motive for zigzagging—"cheating the tide" was the expression used in explanation of the captain's dangerous and reprehensible conduct. Again, if his object had been to lengthen the homeward trip, could he not have achieved this far better and quite safely by proceeding at half speed for as long as he deemed desirable?

I would like to express my appreciation of these historic articles.

JAMES F. VICKERY.

Southend-on-Sea,
September 11th.

[We take this opportunity of apologising to the district of Seven Dials for having translated

it from the Soho area to the East End of London. Our error was made worse by the fact that from the context it might appear that Mr. F. C. Bowen was responsible for it. It was, however, entirely ours.—ED. THE E.]

Sixty Years Ago

A SECOND SUEZ CANAL ?

WITH the British victory at Tel-el-Kebir on September 13th, 1882, Arabi Pasha's rebellion in Egypt collapsed. We had undertaken the brief campaign nominally with the object of upholding the Khedive's authority, but in the background the safety of the Suez Canal was the real stimulant to our exertions. Lord Beaconsfield's purchase of the Khedive's shares in 1875 had made this country a large shareholder in the Canal Company, and it was with anxiety that we saw the safety of the Canal threatened by Arabi and his rebellious soldiery. The situation was saved by the rapidity with which Sir Garnet Wolseley conducted the campaign. It was stated at the time that had he delayed his final blow by as little as eleven hours, the rebels would have destroyed the sides of the Canal at one point and blocked it for an extended period. The possibility that an unfriendly Power might deprive British ships of the use of the Canal was forcibly emphasised by this incident, and in some quarters uneasiness was expressed at the fact that, although we owned a large block of the company's shares, it was still predominantly a French company, and that France would always claim a vested interest in it. To meet this situation, some men's minds began to turn in the direction of constructing a second Canal which would be entirely financed, built, and controlled by this country. It was recalled that in 1855 de Lesseps invited an International Commission consisting of three Englishmen, two Frenchmen, a Dutchman, and an Austrian to consider the practicability of constructing a ship canal across the Isthmus of Suez. The Commission reported in favour of the practicability of the project, but a difference of opinion arose as to the route which the Canal should follow, and its nature. The three English engineers—J. M. Rendel, J. R. McClean, and Charles Manby—recommended that the Canal should be raised 25ft. above sea level, with locks at each end, and fed with fresh water from the Nile. The others advised that it should be cut 27ft. below sea level by dredging and excavating, and their advice was eventually adopted. The proposal to build a second canal resulted in a revival of interest in the English engineers' scheme in favour of which powerful arguments, based on the experience gathered from the construction and operation of the first Canal, were advanced. . . . It need hardly be added that the increasing control over Egyptian affairs which we secured after Arabi's rebellion was quelled, eased the situation, and that the proposal to construct a second Suez Canal ceased to attract interest.

BOOKS RECEIVED

Fundamentals of Vibration Study. By R. G. Manley. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 13s. 6d.

Steels for the User. By R. T. Rolfe. Second edition. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 25s. net.

Oil and Petroleum Year Book, 1942. Compiled by W. E. Skinner. London: W. E. Skinner, 20, Copthall Avenue, E.C.2. Price 10s. 6d. net.

Spectroscopy and Combustion Theory. By A. G. Gaydon. London: Chapman and Hall, Ltd., 11, Henrietta Street, W.C.2. Price 17s. 6d. net.

Workshop Practice in the Light Repair Shop. By A. F. Wilby. London: Edward Arnold and Co., 41–43, Maddox Street, W.1. Price 1s. 6d. net.

Technical Paper No. 38, Lightning Discharge Investigation, I. By J. M. Bryant and M. Newman. *Technical Paper No. 39, The Effect of Fine Aggregate on the Durability of Mortars.* By C. A. Hughes and K. A. Andersen. U.S.A.: Institute of Technology, University of Minnesota, Minneapolis.

Sir Charles Parsons and Mechanical Gearing*

By S. F. DOREY, D.Sc., Wh.Ex.

AS far back as 1897 Parsons had, for the first time, employed a helical gear drive with the second marine turbine built. This machinery was fitted in a 22ft. launch. The gear was single helical and a single pinion was used to drive twin screws.

The epoch-making application of mechanical gearing to marine propulsion was made in the year 1910, when the Parsons Marine Steam Turbine Company fitted a single-reduction turbine installation in the "Vespasian," an old single-screw vessel some 275ft. long. This vessel was originally fitted with triple-expansion steam engines; these engines were thoroughly overhauled and exhaustive trials carried out to ascertain steam consumption. On the completion of these trials the reciprocating machinery was removed and the geared turbine machinery substituted. The propeller, however, was retained to make machinery comparison complete. The details of the gearing were as follows:—

Gear wheel	99½in. p.c.d.
Two pinions	5in. p.c.d.
Face width	24in.
Load per inch of face	350 lb.
Pitch line velocity	2160ft. per minute
Parsons number	$K = P\sqrt{d} = 157$
(where P = load per inch face width, d = p.c.d. of pinion)	
Gear ratio	19·9 : 1
Circular pitch	0·7854in.
Helical angle	20 deg. (double helical)
Material of wheel: Cast iron hub with two forged steel rims shrunk on	
Material of pinions: Mild chrome-nickel steel with a tensile strength of 34 tons per square inch and a yield point of 20 tons per square inch	

The screw shaft revolutions were 83 per minute and the power developed 550 S.H.P. per pinion; the pinion shaft was supported on three bearings and a flexible coupling was fitted between the turbine and pinion. The primary function of this coupling is to break the system axially, thus allowing the pinion to take up a natural position in its own bearings and to allow a balance of loading on the left and right-hand helices. The coupling also serves to accommodate a small amount of misalignment resulting from changing temperatures. The value of this coupling will be discussed later in dealing with Parsons' ingenious handling of the problem of gear noise. The gears for the "Vespasian" were cut by the Power Plant Company, Ltd., on a hobbing machine, being to the design of Parsons both as regards dimensions and type of construction.

After the fitting of turbine machinery trials were again carried out, the results forming a complete comparison of turbine and steam reciprocating machinery. The thoroughness with which these trials were carried out was quite typical of Parsons' method of tackling problems by practical test. The endeavour was richly rewarded, the turbine machinery making an improvement of some 15 per cent. in the overall efficiency. Further, the weight of the reciprocating machinery was 33 per cent. greater than that of the geared turbine installation, and it is of interest to note that the gear efficiency was estimated at 98½ per cent. By this brief summary it has been shown how the advent of the steam turbine in a short time revolutionised marine propulsion so far as high-speed vessels were concerned. The success of the "Vespasian" heralded a new era in turbine propulsion, which in a correspondingly short space of time was to cause an almost complete change over from direct to geared turbine drive.

So far as naval vessels are concerned, in the 1910 programme two torpedo-boat destroyers were ordered, namely, the "Badger" and the "Beaver," in which the high-pressure and cruising turbines were in tandem and delivered 3000 S.H.P. through a single-reduction gear to the propeller-shafting to which the low-pressure turbine was directly coupled. In 1912, the Admiralty went a step further in placing the order for the machinery of the torpedo-boat destroyers "Leonidas" and "Lucifer," each of 22,500 S.H.P. In these vessels, completed in August, 1914, the whole of the power was transmitted through single-reduction gearing, the pinions being arranged on the port and starboard sides of the main wheel and delivering power from the high-pressure and low-pressure turbines. This represents present-day naval practice, excepting that in some cases a cruising turbine is fitted as an extension to the high-pressure spindle.

Before the completion of the torpedo-boat destroyers "Leonidas" and "Lucifer," two light cruisers, the "Calliope" and "Champion," each of 40,000 S.H.P., were ordered, and these were all geared installations. The "Calliope" was a quadruple-screw vessel and the "Champion" a twin-screw vessel, and both were successful in service. In about three years, therefore, from the original adoption of gearing a figure of 20,000 S.H.P. transmitted through one set of gearing was reached. During the 1914–18 war geared turbines were not totally adopted for naval purposes; all warships, however, during that period were fitted with cruising turbines, which delivered power through mechanical gearing. No doubt the adoption of gearing at this time was limited by the number of gear-cutting machines available rather than by considerations affecting the reliability of geared drive. After 1916 practically all warships, excepting special types, were fitted with mechanical gearing, and the powers transmitted rose to 36,000 S.H.P. per gear set. Something of this phenomenal development in geared drive can be realised by considering the total shaft horsepower transmitted through mechanical gearing, which by 1920 reached a grand total for naval vessels of nearly 7 million. This total does not include the shaft horsepower transmitted by cruising turbines. The extended use of mechanical gearing over the comparatively short period of ten years, starting with Parsons' classical trials with the "Vespasian," indicates something of the debt owed by the Royal Navy to the genius behind these achievements. The value of Parsons' work shines even more brightly when it is remembered that much of the progress was made during a critical period for this country, when the failure of gears might well have had disastrous effects on the efficiency of naval vessels.

In the Merchant Service the success of the geared system in the "Vespasian" led to its adoption in Channel steamers, and subsequently in cargo vessels. Lloyd's Register annual returns for the year 1913–14 showed that twenty-three vessels were fitted with mechanical gearing. The year 1914 also

* The Institute of Marine Engineers. The Parsons Memorial Lecture, 1942.

saw the completion of the Anchor Line turbine steamer "Transylvania," a vessel of 14,000 tons. By August, 1914, geared turbines amounting to 260,000 S.H.P. had been built or were building with single-reduction gears.

Double-reduction Gears

The first vessel fitted with double-reduction gearing, as shown by the records of Lloyd's Register of Shipping, was the s.s. "Pacific," of 6000 gross tons, completed in 1915 by the Union Ironworks Company, of San Francisco, the machinery installation being constructed by the General Electric Company, New York.

In this country the first vessel fitted with double-reduction gearing was the s.s. "Somerset," of 9770 gross tons, built in 1918 for the Federal Steam Navigation Company. This was a single-screw vessel of 4500 S.H.P. with propeller running at 85 r.p.m. The gearing was of the "interleaved" type. It is of interest to note that the gears in this vessel were in service until 1933, when they were reconditioned, the secondary gears then being cut with the all-addendum tooth.

The success of the gears in the "Somerset" led to the gradual introduction of the double-reduction system up to 1922–23, when over 1,000,000 S.H.P. had been fitted in this country. Subsequently, however, records from Lloyd's Register indicate that owners showed a preference for the single-reduction gear. In the United States, by 1921 over 2,000,000 S.H.P. had been fitted in about 750 ships with double-reduction gearing, other vessels built up to this period being fitted with single-reduction gears. It seems true to state that one of the difficulties with the double-reduction gear is the heavy mass concentrated at the secondary pinions, such mass being due to the first reduction wheel being rigidly attached to the same shaft. Axial movement of the secondary pinions necessitated by gear-cutting inaccuracies involves much higher inertia loading than is the case with the primary pinion having an adjacent flexible coupling.

The troubles which arose in the early days with double-reduction gearing were mainly those connected with excessive pinion wear, particularly that of the second reduction. The remedies suggested for obviating this trouble were to reduce the load per inch face width in the case of double-reduction gearing, whilst in the United States the "floating frame" type of gear was suggested as a solution to the trouble. Parsons, on the other hand, maintained an uncompromising adherence to the rigid frame type of gear, and held that gear-cutting inaccuracies should be reduced to a minimum, attention being paid to alignment and the maintenance of the necessary stiffness of the second reduction pinion shafts. Development since that date shows how right Parsons was and that, no doubt, he realised well the effects of increased inertia of the pinion shafts already mentioned. At this stage it may be mentioned that measurements have actually been made by Mr. Forsyth on my staff of the shuttle action of the second reduction pinion shafts, *i.e.*, port and starboard, in the case of a gear in which failure of the second reduction pinions had twice occurred. The shuttle action was measured under ordinary running conditions, and was almost identical on the port and starboard sides, indicating errors in the main wheel. The main wheel was re-cut and no further trouble was experienced with these gears. It is interesting to note from this example that it was the second reduction pinions which failed as a result of the inaccuracies in the main wheel.

As regards the "floating frame" it has been definitely established that excessive elasticity in conjunction with gearing can, with the incidence of resonance, set up resonant vibrations leading to excessive gear loads and excessive noise from the gear, and there seems little doubt that Parsons' adherence to rigid frame gears was thoroughly justified.

Whilst the application of double-reduction gearing to slow-speed merchant vessels in this country since about 1923 has not fulfilled the early expectations, it is probable that this must in the main be attributed to the increased economy obtainable with the heavy oil engine rather than to inherent lack of possible reliability in the double-reduction gear.

Materials for Mechanical Reduction Gearing

It is a very remarkable fact that the materials originally selected by Sir Charles Parsons for the gearing of the "Vespasian" were substantially identical in physical properties with those which are in general use to-day, and this in spite of the enormous strides which have been made in the progress of the science of metallurgy during the past thirty years, more especially as regards alloy steels and their heat treatment. That the original materials used have been shown now by long experience to meet the exacting requirements of gearing bears eloquent testimony to the sound judgment and engineering "instinct" which characterised Parsons in every phase of his work.

The properties of materials which experience has shown to be necessary in mechanical gears may be summarised as follows. For pinions, it is necessary to have satisfactory tensile strength to prevent fracture of the teeth at the root, sufficiently high yield strength to minimise the danger of permanent deformations which might arise from abnormal conditions of loading due to impact, vibration, misalignment, or other causes, adequate ductility to assist in the more uniform distribution of stresses, an appropriate degree of hardness to give resistance to wear, and fatigue strength, not so much to withstand the root stresses in the teeth as to enable the tooth flanks to resist the repeated application of high surface stresses. These latter qualities are particularly important in the case of the pinion material, since the surface stresses are higher consequent upon the smaller radius of curvature of the pinion teeth relative to those of the wheel and, further, since the number of applications of load may be anything from six to twelve times as great as on the wheel teeth.

A further important requirement for main gears is that the necessary properties should be obtained without a final heat treatment, subsequent to the cutting of the teeth.

Turning now to the material of gear wheels, the original construction adopted by Sir Charles Parsons in the case of the "Vespasian," namely, forged steel rims shrunk and pinned on a cast iron centre, is still in the main that adopted in the Merchant Service, although cast steel or bolted plate centres are preferred in naval work. For the rims, which are usually of rolled or hollow forged construction, it is a first requirement to use a material which can be readily forged, having a moderately high tensile strength and good ductility, the necessity for hardness and high fatigue strength being less than for the pinion material for the reasons already stated.

For the purpose of comparison, particulars of the materials used in the gearing of the "Vespasian" are shown in Table I, together with typical present-day specifications for materials of pinions and wheel rims.

The pinion forgings are made with sufficient material on the portions from which the teeth are cut to allow 2in. on the diameter being removed before heat treatment, and leaving about ½in. on the diameter for the machining of all surfaces after heat treatment. In the case of naval gears the forging is heated to 850 deg. Cent., quenched in oil and tempered at 600 deg. Cent. The time taken to raise the forging to the required temperature should not exceed half an hour.

In connection with the use of nickel steel forgings for pinions, it may be mentioned that some troubles were experienced in the post-war years of 1921–22 due to the cracking of nickel steel pinions. It was at first thought that this was brought about by contraction stresses in quenching and tempering, but it is probable that the troubles experienced were initiated by defects in the material which showed itself particularly liable to develop hardening cracks. Whatever the true cause may have been, it may be noted that since then the great majority of nickel steel pinions for the Mercantile Marine have been normalised only, although for naval gears the oil hardening and tempering process has been continued. A very important point with regard to the material of pinions is the amount of discard to be removed from the ingots before forging. In average practice to-day at least 40 per cent. of the total weight of ingot is removed from the top end and these proportions are usually sufficient to ensure freedom from piping and segregation. A further precaution against the occurrence of such defects is the boring of the pinion forging for its whole length prior to heat treatment, and this has the added advantage of promoting a more homogeneous structure, particularly in pinions of large diameter in which mass effects may be important.

As regards alternative materials for gear wheels, in some cases, particularly in American practice for second reduction gears, the wheels are steel castings without special rims. Among the advantages that are claimed for this material are:—

(1) Improved physical properties can be obtained as compared with rolled material, particularly as regards hardness.

(2) Reduction of strength due to the occurrence of blow-holes or cavities in well-designed steel castings is less serious than if the same flaws were rolled out in the form of cleavage planes from ingot castings.

(3) Internal stresses in large castings can be eliminated by annealing and normalising, whereas with shrunk rims internal stresses are always present, and further, the distribution of shrinkage grip is never uniform around a solid centre.

(4) Reduced weight and cost.

For such steel castings it is usual to employ a carbon content of between 0·20 and 0·35 per cent., with the addition of from 0·40 to 0·60 per cent. of molybdenum. It is claimed that molybdenum confers increased hardness, whilst reducing mass effect in heat treatment, and improves the machining qualities of the casting. The physical properties of a cast carbon molybdenum steel would be U.T.S. 31 tons, Y.P. 20 tons, elongation (2in.) 22 per cent., reduction of area 35 per cent.

Gear Noise and Periodic Errors

The first two gear-cutting machines were installed in the works of the Parsons Marine Steam Turbine Company in 1910. These were "solid table" hobbing machines and, judged from present-day standards, the worm periodic error in the gear was somewhat pronounced, amounting, as stated by Parsons, to a double amplitude of 4/1000in.

Making use of a microphone and oscillograph, Parsons established that the noise frequency corresponded to the number of

teeth in the worm wheel of the gear-cutting machine multiplied by the revolutions of the wheel. By 1913 Parsons had introduced his ingenious "creeping" table machine and there is little doubt that even to-day the advantages to be gained by the use of this machine, together with those accruing from the provision of longitudinal freedom given by a flexible coupling, have made the best contribution towards the reduction of gear noise.

In the case of gears cut on solid table machines, the predominant frequencies in the noise are :—

(1) Tooth contact frequency.
(2) Worm wheel tooth frequency.
(3) Tooth frequencies of the worm wheel of previous hobbing machines used in the manufacture of the gear-cutting machine which cut the gear.
(4) Feed screw periodic, due to one revolution of the feed screw.

Regarding frequencies under (3), these have been spoken of as the "hereditary taint" and actual noise has definitely established the truth of this statement. The tooth contact frequency is given by the rate at which the teeth run into mesh.

The worm wheel frequency results from a periodic error in the worm, with its abutments used for driving the work table. This results in a periodic motion of the table superimposed on its mean rotation during gear cutting. It is obvious that on a helical gear such periodic movements will give rise to undulations along the tooth faces. Furthermore, it can be seen that the crests and troughs of such undulations from tooth space to tooth space will lie in the same axial plane. With a worm error of the order mentioned by Parsons of $\pm 2/1000$in. the meshing of the teeth occurs more like a spur gear having the same number of teeth as the worm wheel of the gear-cutting machine. The advantages of the helical form are thus lost. In a single-helical gear the undulation gives rise to a torsional and axial vibration of the gear wheel. With the double-helical gear the vibration is again torsional and axial, but the magnitude depends upon the phase relation of the undulation on the two helices. The magnitude of the movements may be greatly increased by the incidence of resonance in the case of gears rigidly connected to mass elastic systems. As a result of such resonance, tooth loads can easily exceed the fatigue strength of the teeth and failure occurs. The resonance is also invariably associated with intense or "harsh" gear noise. Nor is it a matter of coincidence that resonance occurs. There are present many torsional and axial frequencies in the range of frequencies which may be excited by gear-cutting inaccuracies in the case of a rigidly coupled system, when both mass and elasticity of shafting are taken into account. Parsons' idea of introducing a flexible coupling between the pinion and turbine did much towards eliminating the danger of resonance and consequent heavy tooth loading. Although the main gear wheel was rigidly coupled to the line shafting, the forces exerted on the wheel, due to the "shuttle" action of the pinion, were greatly reduced by the pinions being flexibly connected.

The undulation introduced by periodics in the gear-cutting machines can now be accurately measured by an instrument† developed at the National Physical Laboratory. The wave length of the undulation due to the worm error in a solid table machine is given by the formula, viz.:—

$$\lambda = \frac{n}{m} p_c \operatorname{cosec} \delta$$

where

λ = wave length in inches,
δ = spiral angle,
n = number of teeth in the gear,
m = number of teeth in the worm wheel of the gear-cutting machine,
p_c = circular pitch of gear.

Fig. 1 shows a record taken by this instrument, giving the worm periodic in a solid table machine.

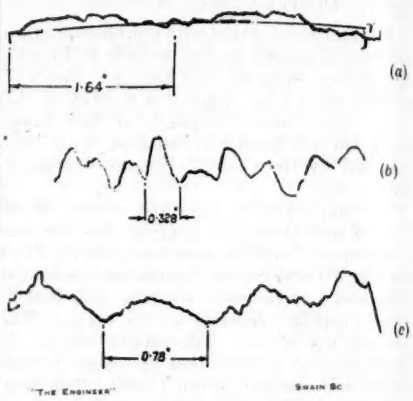
The feed screw periodic generally gives a much shorter wave length undulation than that caused by the worm error. Since the axial length is equal to one pitch of the feed screw, the wave length along the tooth space is given by the formula

$$\lambda = p_f \sec \delta,$$

where p_f = pitch of feed screw.

The phase of this undulation is nearly constant round the wheel. The crests and troughs of these undulations may or may not lie in the same axial planes ; in both above respects they resemble the cumulative worm wheel undulation of a creep gear, as will be shown later.

In solid table machines the errors most likely to occur are those due to the worm gear. It is important that the curve of the cumulative division error of the worm wheel, from tooth to tooth, should be as smooth as possible. In this way the cumulative error will not set up undulations demanding rapid accelerations and decelerations of the gear wheel, but will appear more as a helix angle error.



(a) Record shows worm error undulation in gear cut on solid table machine, double amplitude of undulation 0·0004in., wave length 1·64in.
(b) Record shows cumulative error undulation in R.H. helix of gear cut on creep machine, maximum double amplitude 0·0012in., wave length 0·328in.
(c) Record shows undulation due to worm error in L.H. helix of same gear as (b) above, i.e., cut on creep machine, maximum double amplitude 0·0009in., wave length 0·78in.
NOTE.—The creep arrangement in the machine was as shown in Fig. 5 (*post*) and the worm wheel and spur creep had an equal number of teeth ; consequently there was an exact whole number of revolutions of the worm per revolution of the work. Thus the effect of creep in reducing the worm error and dispersing it in a spiral was lost.

FIG. 1—UNDULATION RECORDS

Much has been done in recent years to eliminate the periodic errors in solid table machines ; it is true to say that undulation records indicate that such errors have almost been eliminated by a few firms. On the other hand, creep machines generally indicate a greater magnitude of undulations than gears cut on good solid table machines. In this connection it is interesting to study the undulation records in Fig. 1. In spite of this, however, it seems generally agreed that gears cut on creep machines are more silent than those on solid table machines. The conclusion to be drawn is that the value of the creep machine consists in placing the periodics spirally round the gear instead of in the same axial plane, rather than in reducing the magnitude of the undulations due to periodics.

Solid table machines have also been made

TABLE I

	Type of material.	Mechanical properties. U.T.S. tons per sq. in.	E.L. tons per sq. in.	Y.P. tons per sq. in.	Elong. (2in.) per cent.	R.A., per cent.	Izod impact ft.-lb.	Bend test.	Chemical composition, per cent. C.	Si.	Mn.	S.	P.	Ni.	Cr.	Heat treatment.
PINIONS. S.s. "Vespasian" ...	Forged Ni-Cr steel	33·8	9·3	19·8	34	66	—	—	0·16	0·13	0·461	0·019	0·018	3·46	0·53	Annealed
Typical modern specification	3½ per cent. Ni steel	40 min. (L. & T.)	—	24 min. (L. & T.)	20 (L.) min. 16 (T.) min.	—	35 min. (L.)	† 180 deg. (L. & T.)	0·24 to 0·35	0·25 max.	0·50 to 0·80	0·04 max.	0·04 max.	3·25 to 3·75	—	Normalised
WHEEL RIMS. S.s. "Vespasian" ...	Forged carbon steel	30 to 35	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Typical modern specification	Rolled carbon steel	31 to 35	—	—	26	—	—	180 deg. ‡	*	—	—	—	—	—	—	Normalised

† Bend test, ¾in. by ⅜in. over ¾in. radius. ‡ Bend test, 1in. square over ¾in. radius. * Carbon content as required to give mechanical properties.

NOTE.—In American practice for shrunk rims of first and second reduction wheels the carbon content and ultimate tensile strength are somewhat higher, a typical specification being as follows, viz., U.T.S. 36 tons per square inch, Y.P. 20 tons per square inch, elongation (2in.) 22 per cent., R.A. 40 per cent., B.H.N. 160–190. Heat treatment : annealed or normalised and tempered.

† This instrument was designed by Dr. G. A. Tomlinson, Metrology Department, N.P.L.

with a large number of teeth in the worm wheel with a view to raising the frequency of the noise even above the audible range of frequency. Such attempts have succeeded in reducing noise level, but frequencies have been present corresponding to the number of teeth in the worm wheels of the gear-cutting machines used in producing the worm wheel with the larger number of teeth. It seems, therefore, that the elimination as far as possible of the periodic error is the correct solution, whether or not the number of teeth in the worm wheel is increased.

(To be continued)

The Magnetic Powder Method of Crack Detection

By J. FERDINAND KAYSER, Assoc. Met.

IN order to detect cracks by the magnetic powder method, the specimen is magnetised and then dusted with dry magnetic powder or sprayed or submerged in a liquid carrying a magnetic powder in suspension. In general, electro-magnetic means are used to effect the magnetisation. These means may consist of an electro-magnet comprising an iron core or yoke and a current-carrying winding or a source for producing a heavy current that may be passed through the specimen under examination. D.C. or A.C. may be used. From the point of view of convenience A.C. is probably preferable, but equally satisfactory detection is possible by use of D.C. The disadvantage of D.C. is that its voltage cannot so readily be stepped up and down. It must, however, not be forgotten that for magnetising purposes one may use a transformer in conjunction with D.C.

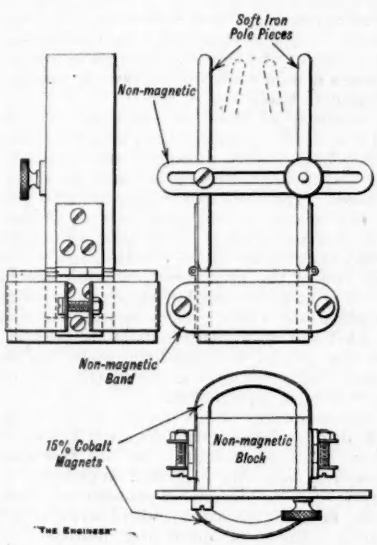


FIG. 1

The cross section of the core of an electro-magnet and the number of ampere turns must be so chosen that the former is sufficiently large to carry the required flux and the latter sufficient to supply the magneto-motive force necessary to magnetise the sample to the required degree. The number of ampere turns must, of course, be directly proportional to the length of steel being magnetised.

Experiments have shown that the exact degree of magnetisation is not critical. The magnetising force must be ample; but, on the other hand, no increase in sensitivity is obtained if one increases the magnetising force beyond quite moderate limits. In fact, it is detrimental, because when the magnetising force is increased above about 120 C.G.S. units the magnetic powder is retained by the sound surface as well as by cracks and similar discontinuities. The most suitable magnetising force appears to be one in the vicinity of 100 C.G.S. units, *i.e.*, 80 ampere turns per centimetre length.

When it is necessary to magnetise very long articles, say, more than 10in. long, it appears that it is probably more economical to use electro-magnetic means, but shorter lengths may well be magnetised with permanent magnets. Furthermore, it is possible to examine portions of a large specimen by the use of a permanent magnet.

The design of permanent magnet circuits has been adequately dealt with by Evershed,* and the economics of the substitution of electro-magnets by permanent magnets has been exhaustively examined by E. A. Watson.† It is hence not proposed again to deal with this subject, but briefly to indicate the application of the known principles to the design of permanent magnets suitable for crack detection.

For some purposes the apparatus may be made up wholly of permanent magnet steel, whilst for other purposes it may be preferable to have movable pole pieces, when one must necessarily resort to a circuit comprising both permanent magnet steel and soft iron or mild steel.

The design (*i.e.*, dimensions and shape) of the permanent magnet circuit must be such that on open circuit it will not become demagnetised below the B $H_{max.}$ point of the steel from which the permanent magnet is made. Furthermore, the length of the permanent magnet will have to be proportional to the length of the article it is required to magnetise and the cross section of the permanent magnet must be sufficiently great to provide the necessary flux. The length is easily determined, but the determination of the necessary cross section of magnet steel is somewhat more involved because one must make provision for leakage.

If the limbs are fixed the length magnetised by the magnet is also fixed, and if the magnet is used in conjunction with articles with flat surfaces it will be equal to the distance between the limbs. Assuming that one decides to make the permanent magnet from tungsten steel, one may for simplicity assume an available magnetomotive force of 33½ C.G.S. units per centimetre length of magnet. In order to produce a magnetising force of 100 C.G.S. units in a rectangular bar of steel placed across the poles one may assume that the tungsten steel magnet must be three times as long as the piece of steel in question. If, on the other hand, one decided to make the magnet from 35 per cent. cobalt steel having an available magnetomotive force of 150 C.G.S. units, the permanent magnet need only be two-thirds as long as the sample it is required to magnetise. The cross section of the magnet must be sufficiently great to meet the flux requirements, but the exact size is not important as long as it is comparable with that of the cross section of the piece being tested.

A construction utilising two permanent magnets acting in parallel and giving contact to the piece under test by means of mild steel pole pieces is illustrated in Fig. 1. Innumerable designs are possible, but not necessary, and it is probable that some half-dozen differently sized pieces of apparatus would meet all requirements.

* *Journal* of Institution of Electrical Engineers, Vol. 58, page 780.

† *Journal* of Institution of Electrical Engineers, Vol. 63, page 822.

Civil Engineers and the Building Trade

IN THE ENGINEER for September 4th, page 186, we dealt with a Conference at the Institution of Civil Engineers on August 24th, when the position of civil engineering *vis-à-vis* the building trade was discussed generally. The first of the subsequent five monthly meetings to consider specific problems emerging from that Conference was held at the Institution on Tuesday, September 15th, the principal speaker on that occasion being Mr. George Hicks, M.P., Parliamentary Secretary to the Ministry of Works and Planning. The President of the Institution, Professor C. E. Inglis, was in the chair, and the subject matter for discussion was "The Structure of the Building Industry: Its Component Parts; the Position of the Operative; the Relation of the Architect, the Engineer, and the Surveyor." The first four speakers were selected to deal with these various aspects, after which there was a general discussion.

Clearly from these five meetings there will be a mass of material to be sifted and classified if definite decisions are to be arrived at. In general meetings of this nature it is quite impossible to frame proposals, and some committee and perhaps sub-committees will have to be formed ultimately to co-ordinate the various views expressed. These meetings are probably intended to be of an exploratory nature, and it may be that the subsequent ones will produce something more specific. One's impression on Tuesday last was that there was a certain amount of reiteration in many respects of what was said at the main Conference on August 24th, and rather too much in the way of a general view, with too little precision in proposals. But for the anticipation of more detailed schemes being put forward at the subsequent meetings, there might almost be a feeling of disappointment with this first of the series.

Mr. George Hicks, M.P., Parliamentary Secretary to the Ministry of Works and Planning, in a review of the component parts of the building industry, pointed out what was emphasised previously, viz., the vast number of other industries and professions which are now comprised in the term "building industry." He drew a distinction between building as generally known (in so far as it relates to the erection of buildings of various types) and public works, bridges, roads, railways, and general civil engineering projects, and spoke of the difficulty of trying to understand where one branch ends and another starts. Mentioning the scope in "building" for the civil engineer, the architect, the quantity surveyor, the structural engineer, the mechanical engineer, the electrical engineer, the sanitary engineer, and the heating and ventilating engineer, he also brought in the various specialists who must be considered to make the picture complete, following this up with a comment on the operatives' side. Separating from all this what is known in the public mind as "the building industry," he alleged that this seemed to have been neglected in the body politic, and has never been properly understood. That might be due to faulty

propaganda and inability to get their story over to the public, and perhaps insufficient money, time, and effort had been spent to make the country appreciate fully the significance and importance of the building industry. Whatever the reason, he claimed that the average man did not understand how important the building trade is to national life, and to improve this state of affairs there was need for a better organisation of the trade as a whole. He added that he had plenty of ideas on that matter, but would not give them at the moment. (It is to be hoped they will be forthcoming later, for surely that is one of the main purposes of these meetings.)

From this he passed on to another point amply dealt with on the previous occasion, the importance of providing continuity of employment in the building industry—and here, of course, he came to the operatives' side. There could not be an efficient industry unless it be an employed industry.

Touching on some of the broader aspects, he suggested the architect must be regarded as a co-ordinator of the work of the many specialists now necessary in the building trade, the day having passed when the master builder could handle all the technical needs of a building. There might even be a case for a separate profession of co-ordinators. Of the engineer, confining himself to the civil engineer and the structural engineer, he admitted there are certain classes of work coming within the general term "the building industry" for which the engineer is more qualified than anyone else, although from the point of view of æsthetics it might be well, in certain cases, to consult a good architect. There was no fundamental difference between good engineering and good architecture. Civil engineering at its highest and best became good architecture, and in support of this view he mentioned the Chelsea Suspension Bridge.

Stress was laid on the manner in which the war has brought about a much closer concentration between the various interests involved in the building trade; it was urged that the outstanding difficulties were capable of adjustment, and, in general, Mr. Hicks appealed for co-operation between employers and operatives, engineers and architects, professional bodies and individuals. He added that there are 530 associations, federations, and organisations in the building industry, of which 38 are professional, 28 operative, 295 employers, and 170 building material manufacturers and distributors, and hinted that a great deal of rationalisation was wanted there.

Expressing a final hope that such organisation as was necessary would be built up on a national basis after the war, Mr. Hicks, speaking of the shape of things to come, said that dreaming will not do. Sturdy action was called for on the part of the Government and the industry, for the building industry, in the widest meaning of the term, would have to carry a great part of the burden of repairing the ravages of the war and bringing the country back to a peaceful way of life. We must not wait for something to turn up.

Mr. Luke Fawcett, General Secretary, Amalgamated Union of Building Trade Workers, regretted the depreciation in craftsmanship since the last war, contributing factors in which he said were the increase in standardisation and lack of opportunity to apply craft from the craftsman's point of view. Asking for assistance in improving the general standard of craftsmanship, he spoke of steps being taken to reintroduce the old apprenticeship system and the provision of education facilities, none of which, however, could be effective in the absence of means for preventing casual employment in the industry. There must be security of employment, and wartime conditions had demonstrated the possibility of that.

Mr. Alan V. Davson, Chairman, Quantity Surveyors' Committee, Chartered Surveyors' Institution, spoke of the manner in which quantity surveying has grown to be a separate profession, and pointed out that the increasing use of steel and concrete after the war, due to lack of supplies of timber, would call for a greater use of the services of the quantity surveyor. Incidentally, he challenged the view that the functions of the architect and the engineer might merge.

Mr. G. H. Parker, Chairman, Advisory Council for the Building Industry, spoke with satisfaction of the improvement in the relations between employers and operatives in the building trade during the past thirty years, and urged that if there was to be an efficient industry in all respects there must be 100 per cent. organisation on the part of the employers and 100 per cent. organisation on the part of the operatives.

Mr. E. L. V. Dakin (Messrs. Wilson, Lovatt and Son, public works and building contractors), said difficulties were in the way to-day due to too much suspicion, for the simple reason that the industry was ruled by the yardstick of cost. To get efficiency there must be contented workmen, but in many instances at the present time the operative did not know where he stood. He was not paid for "wet" time, but there was no reason why he should not be paid at least 50 per cent. of the standard wage in wet weather, for it was not his fault. The problem, however, was where to include that in the estimates. Another reform he suggested was that for the first fourteen days of his employment a man should be subject to an hour's notice, to enable the employer to sort out suitable men, but after that there should be one week's notice. Another source of trouble was that very often the contractor's agent was far more qualified than the resident engineer or clerk of works, and yet he had to take orders from them. Only when resident engineers and clerks of works were more qualified would there be hope of co-ordination with the contractor's agent. Another suggestion was that as building works generally now call for the services of the engineer and architect in a 50 : 50 proportion, the one should receive architectural training and the other engineering training.

Mr. Leslie Turner (consulting civil engineer) looked to the time when the central government and local government authorities would employ technical men who ranked equally with those holding high administrative posts. Recommending the establishment of schools for operatives, he said those had been created in America with marked success, and it was satisfactory to know that both the Institution of Civil Engineers and the Institution of Structural Engineers were taking action in that matter. He did not think we needed to be afraid of over-standardisation, and looked to simplification, and, finally, urged that we should go wholeheartedly over to the metric system.

Mr. Harry Jackson (consulting civil engineer) advocated a change of attitude towards operatives from the old one of patronage, and, so far as the industry as a whole was concerned, suggested it would not be wise to lump it all together as one. It should be sectionalised, so that there would be an engineer dealing with the major engineering works, an architect dealing with the buildings, a surveyor to deal with quantities, prices, &c., and so on. This would give a scheme of control which could be subdivided at its various points so as to bring in the specialist where necessary. In this connection there was a great opportunity for the professional institutions to get closer together and to take definite responsibility for such subdivision and responsibility.

Mr. G. R. Faulkner Nuttall (consulting civil engineer) discussed training for young men to encourage them to enter the industry, and suggested steps should also be taken now to provide refresher courses for men coming out of the Forces after the war and training for those coming out of munitions factories and wishing to enter the industry. He also stressed the need for continuity of employment in the building industry.

Mr. W. H. Smith (consulting mechanical engineer) pressed for greater mechanisation in the building industry, adding that he did not think there was a less mechanised industry in the country.

The discussion then closed. The next meeting will be held on October 13th, when the economics of building and the financial implications in post-war reconstruction will be considered.

Plastics in Aircraft Construction*

By GEORGE W. DEBELL

MANY engineers look upon plastics and allied materials as entirely new to the aircraft industry, but such is not the case. Phenol fibre sheet and resin-bonded waterproof plywood have been used for years, and acrylic resin sheet has been in use for transparent enclosures for some time past, yet all come under the above category. The primary difference between the past and present uses of these materials is that they are now used in applications where structural loads are involved, while they were previously used only in non-stressed parts, where special characteristics, such as transparency or insulating qualities, were of paramount importance. If these materials are classified according to their major characteristics, they fall into three categories, namely, those made with thermosetting resins, those made with thermoplastic resins, and those made with wood veneer. This classification also in a general way divides them according to their principal uses, thermosetting materials being used mostly in the production of relatively small structural parts, the thermoplastics being used mostly for their transparent properties, and the wood veneer materials being used mostly in relatively large structural parts and assemblies.

THERMOSETTING MATERIALS

The thermosetting materials, as their name implies, are materials manufactured with resins that, upon complete polymerisation, become infusible solids that will not soften when heated. The polymerisation of this class of resin can be attained in either of two ways: by the initial application of heat or by the use of a chemical accelerator. Polymerisation by means of heat is the method in general use, with the exception of the cold-setting resin adhesives, which are generally completely cured by the introduction of a chemical accelerator, although in certain instances a minor amount of heat is essential to complete cure.

A majority of the thermosetting materials used in aircraft is manufactured with the phenol formaldehyde resins, although urea formaldehyde and melamine resins are used in certain instances. The melamine resins are relatively new and are at present used only as thermosetting surface coatings where their permanent transparency is a distinct advantage. The major use of the urea formaldehyde resins in aircraft is as adhesives, but they are also used in applications where a thermosetting material is needed and where light colours are essential, since the phenol formaldehyde resin has an inherent mahogany brown colour that prevents its use in such applications.

Large quantities of low-impact phenol formaldehyde materials are used commercially in the various non-defence industries, but this class of material has only a limited application to aircraft, since its low impact strength precludes its use in all applications where there is the slightest danger of accidental damage. It is therefore relegated largely to the manufacture of control knobs and like parts. The high-impact phenol formaldehyde materials have, however, mechanical properties that justify their extensive use in aircraft where the structural loads are not excessive. Such applications as radio masts, control quadrants, brackets in the bomb release system, equipment support brackets, and housings are well within the design limits of this material. Although this material might possibly be utilised for the manufacture of primary structural units, such as control columns and highly stressed brackets in the primary control systems, it is not felt that our design knowledge has progressed to the point where such applications could be safely undertaken without extensive design research and static testing.

Three methods are used for manufacturing parts from this material: they may be machined from sheet, tube, or bar stock, they may be moulded from laminated material, and they

* Paper presented at the annual meeting of the Institute of the Aeronautical Sciences, New York, January 29th, 1942.

may be moulded from high-impact moulding material. The first method has been used for years and needs no discussion. The second method consists of impregnating sheets of cloth or paper with the uncured resin and forming and curing the desired number of layers of this material to the required shape in heated steel dies. Since the cloth or paper sheets used can only be formed or stretched to a reasonable degree without tearing, this process is limited to relatively simple shapes, such as channels, angles, and shallow pans. The third method consists of impregnating macerated or shredded fabric with the uncured resin, then pouring the impregnated material into the cavity of a heated steel die and curing and moulding to the desired shape under high pressure.

Thermoplastic Materials

The thermoplastic materials consist of those fully polymerised synthetic resin materials that will soften and become plastic upon application of heat. Under this classification fall the acrylics, notably "Plexiglas" and "Lucite," the cellulose acetates, polystyrene, the vinyls, and others too numerous to mention.

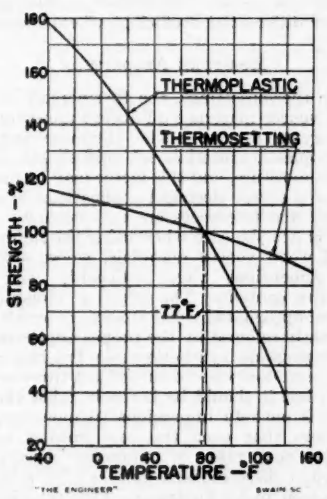
At the present time the acrylics are by far the most important from an aircraft standpoint, although there is a possibility that in the near future some of the cellulose acetates and vinyls may also be used to an appreciable extent. The greatest use for these materials is in transparent enclosures where their clarity, combined with light weight, is of sufficient importance to offset their low scratch resistance and variation in strength with temperature. They can also be used to a limited degree in internal non-stressed parts, such as control knobs, instrument dial faces and placards, where their high rate of change of strength with temperature is of little importance. They should not, however, be used in any stressed application unless a thorough analysis has been made of the temperature effects. In this regard the effects of the radiant heat of the sun should be carefully considered and taken into account. One of the principal reasons that these materials have proved successful in transparent enclosures is that because of their high light transmitting efficiency they do not absorb the radiant heat of the sun to the same extent as dark coloured or opaque materials and therefore attain a temperature only slightly above that of the ambient air. However, if the thermoplastic materials are used in opaque form or are mounted in intimate contact with opaque surfaces, their temperature will rise appreciably because of the effects of radiant heat, and this rise in temperature will be accompanied by a marked lowering in some of their physical properties and in their resistance to cold flow.

Two methods are used for manufacturing parts from these materials: (1) sheet stock is heated until soft and stretched over forms of the desired shape or is pressed in the desired shape in heated dies; and (2) granulated material is moulded to the desired shape in heated dies of either the compression or injection type. In either process the material must be cooled before being removed from the form or die in order to prevent distortion while the piece is being stripped.

Wood Veneer Materials

Wood veneer materials are normally supplied in the form of either flat or moulded plywood, in which the grain of adjacent plies is crossed or in the form of laminated wood, in which the grain of all plies is parallel. The material may be supplied either impregnated or unimpregnated, but up to the present time almost all the material is of the unimpregnated type, the impregnated wood veneers being limited mainly to propeller blanks. The unimpregnated wood veneer materials are generally bonded with a thermosetting synthetic resin adhesive, although thermoplastic adhesives have been used to some extent. For maximum durability and resistance to moisture, hot-setting adhesives of the thermosetting type are preferred. Wood veneer materials made with the cold-setting thermosetting adhesives are believed to be slightly inferior under extreme conditions of moisture and heat, but within the normal aircraft operating range it is felt that this inferiority will not be evident. The best combination of serviceability and manufacturing facility can be attained by using the hot-setting thermosetting adhesives for the manufacture of the plywood sheets and the cold-setting thermosetting materials for the manufacture of the heavy frame members and for assembly.

When the hot-setting type of adhesives is used in the manufacture of heavy members there is always the danger of damaging the wood by excessive heat, since the curing time is a direct function of the thickness of the member. Serviceability of the thermoplastic adhesives in aircraft construction has yet to be conclusively proved, since there is still considerable question regarding the effect of cold flow of the adhesive at the maximum temperatures which may be experienced in tropical service. Existing information on this subject is contradictory, and it is therefore recommended that when such thermoplastic adhesives are used extreme care be exercised to ensure that the glue lines are not highly stressed. Plywood made with such adhesives will probably, in most cases, be satisfactory, since the stresses in plywood glue lines are usually low, but in framing joints this is not usually the case. The thermosetting adhesives available at present are of the phenol formaldehyde and urea formaldehyde types and are offered in both cold and hot-setting varieties. The thermoplastic adhesives in use at present are usually based on the vinyl resins or cellulosic



Effect of Temperature on Strength

compounds. Casein, blood albumen, and other protein plastics should, in general, be avoided as they are subject to bacteria and fungus attack, which cannot be conveniently detected until failure occurs. Such attack of the protein plastics is prevalent in hot humid climates as would normally be experienced when operating in the Tropics.

Impregnated wood veneer materials for general use in aircraft construction are just now becoming available, but their utilisation and further development should be sponsored to the maximum possible degree, since they are much stronger and stiffer than the ordinary laminated thermosetting plastics and can be moulded at appreciably lower pressures. The Forest Products Laboratory research on these materials has indicated that by proper impregnation the ultimate swelling due to moisture absorption can be reduced to somewhat less than one-third of the swelling of normal unimpregnated wood and that the rate of moisture absorption and swelling can be reduced many fold. Their research also indicates that this reduction in ultimate moisture absorption and swelling is practically independent of the density of the resulting material; for example, starting with spruce veneer, impregnated materials can be produced of any density from 0·6 to 1·5. The physical properties of these materials will, in general, vary almost directly with the density, although the increase in certain factors is, of course, not quite so rapid. Laboratory samples of material having 1·4 density have indicated tensile strengths as high as 50,000 lb. per square inch, compression strengths are in the neighbourhood of 35,000 lb. per square inch, and moduli of elasticity are in the neighbourhood of 4,000,000 lb. per square inch.

Design Considerations Affecting Utilisation

If the foregoing materials are to be successfully utilised, it is essential that the basic design of the parts be established by engineers who are fully cognisant of the aircraft manufacturing and operating problems, of the plastic manufacturers' problems, and of the physical properties of the material under consideration. Such design control can be accomplished in any of three ways: (1) the design can be turned over entirely to the plastic manufacturer for development; (2) the design can be handled by the aircraft manufacturer working in co-operation with a particular plastic manufacturer; and (3) the design can be handled completely by the aircraft manufacturer.

The first method does not offer much hope of success, since few, if any, of the plastic manufacturers employ engineers who are sufficiently skilled in the manufacturing and operating problems of aircraft to produce a part entirely satisfactory from all standpoints. The second method has the disadvantage that the aircraft company must initially select a particular plastics manufacturer with whom to work on each particular application; this eliminates the advantages of competitive bidding and oftentimes the plastic manufacturer selected is not the best source for the part under consideration. Also, in this method there is a tendency to design the part around the existing equipment of that particular manufacturer, even though this may make for an inferior design. The third method appears to have the fewest drawbacks, in that a skilled aircraft engineer can, in a reasonable length of time, become familiar with the general problems of the plastic manufacturers and can then produce a design that closely meets the requirements of everybody concerned. The design can then be sent out for competitive bidding and the final details worked out with the company selected to manufacture the part.

Experience has shown that the first and second methods are much more time-consuming than the third, since much more *liaison* is required between the aircraft manufacturer and the plastic manufacturer. When the third method is used, design differences can generally be cleared up in a single conference, and on a majority of parts no conference at all is required. This procedure also makes for a more equitable distribution of responsibility, for the aircraft manufacturer is then responsible for the suitability of the application and its proper functioning and the plastic manufacturer is responsible for the integrity of the part itself from both a dimensional and materials standpoint.

Aircraft Factors Affecting Design

In order that plastics and allied materials may be utilised successfully in the manufacture of aircraft parts, several factors that are not normally considered in metal construction must be taken into account.

Temperature.—The most important of these factors is the effect of the operating temperature range. For a majority of aircraft parts this range is from −70 deg. to +160 deg. Fah., the lower temperature limit being that which may be obtained in the Arctic or in the stratosphere, and the upper temperature limit representing temperature that can be obtained in the Tropics, including the effect of the radiant heat of the sun. This upper limit is not considered to be excessive, as 190 deg. Fah. has been obtained in tests of road surface temperatures in Southern California. The relative effect of this temperature range on the tensile compressive and flexural strengths of the thermosetting and thermoplastic materials is shown in the diagram. The effect of temperature on the unimpregnated wood veneer materials is slight, provided no change in moisture content occurs. It will be noticed that the thermoplastic materials have, in general, a much greater change in strength with temperature, but this is only part of the

story, as they also have a much greater tendency to cold flow at the higher temperature limit and therefore the allowable stress at high temperature for the t ermoplastics must be reduced even further than shown in the diagram.

Impact Strength.—The second most important factor is the influence of the low impact strength of these materials on the possibility of accidental damage during installation and service. Although the thermosetting and thermoplastic materials are greatly inferior to aluminium alloy in impact strength, this does not indicate that they are inferior when used in properly selected and designed aircraft parts. Their lower impact strength is, in most cases, offset by their lower density, which permits the use of sections at least twice as thi k when designed in plastics.

Weight Requirements.—Many people have advocated the use of plastics on the basis of weight saving, and, although this is true to a certain extent, it should not be carried to extremes or the resulting parts will be too fragile and flexible for satisfactory service operation. In general, it is better to design the plastic part for a weight equivalent to that of its metal counterpart, and thereby avoid the possibility of producing parts that are unsatisfactory in service. Usually, if the draughtsman is told that the plastic part is to be made for a weight equal to, or less than, the equivalent metal part, he will produce a unit that is 5 to 10 per cent. under the allowed weight, yet perfectly satisfactory from a manufacturing and operating standpoint.

Resistance to Wear

The problem of wear on plastic parts can usually be controlled through proper use of inserts. In deciding where to put inserts, the designer should take into account the expected service life, the type of wear involved, the bearing stresses developed, and the type of lubrication which will be supplied. Wherever screw threads are called for, it is advisable to use inserts so that the threads will be entirely of metal, as plastic threads, particularly in the smaller sizes, are subject to chipping, and when tightened have a tendency to seize on the screw so that the plastic thread is destroyed when the screw is removed. It is, however, permissible to use plastic threads in certain instances where the thread is merely an assembly feature to simplify mould design, but in such instances an adhesive is usually applied to the threads so that the pieces cannot again be disassembled.

Plastics should be used for the bearings of rotating shafts only when the bearing stresses and speeds are low and when friction is not an important consideration; otherwise, it is advisable to use metallic inserts in such positions. In this regard, Oilite bushings may be used as moulded-in inserts, provided they are not filled with oil at the time of moulding. The porosity of this type of bearing provides an excellent bond between the insert and the plastic and at the same time the bushing only fills up with resin for a depth of about twelve-thousandths from the surface. After moulding, the part is then submerged in hot oil to impregnate the bushings. However, when such porous bushings are moulded into the plastic part, it is essential that the mould pins over which the bushings are placed in the mould be close fits for the bushings, otherwise there is danger of the resin running in between the bushing and the mould pin and sealing the operating surface of the bushing.

In certain specific applications, the thermosetting pl stics have proved themselves superior to the metals as bearing materials. This is evidenced by the use of fabric-base phenolic laminated timing gears in the majority of automobile engines, and by the use of fabric-base phenolic laminated bearings in heavy rolling mill equipment. In the rolling mill application the bearings are lubricated with water, while in the timing gear applications they are, of course, lubricated with oil in the normal manner. When quietness of operation under vibrating conditions is desired, thermosetting plastics offer considerable value as bearing materials, provided due precaution is taken to ensure that the allowable loads are not exceeded and that adequate lubrication is provided. The aforementioned timing gear application comes in this category.

Coefficient of Expansion

When relatively large plastic parts are rigidly mounted to metal supporting structures, due account should be taken of the differential coefficient of temperature expansion of the two materials. It should be remembered that the parts may be assembled at 90 deg. Fah. and then operated at −70 deg. Fah., thereby producing stresses and strains equivalent to the differential coefficient of expansion times the temperature difference of 160 deg. Fah. Such stresses and strains may be an appreciable percentage of the allowable stress and therefore care must be exercised to ensure that the sum of these stresses and the normal design stresses do not exceed the allowable. Oftentimes these temperature stresses may be eliminated or materially reduced by utilising a mounting method that permits relative motion between the plastic part and its metallic supporting structure. This relative expansion problem is not usually important on small plastic parts, such as brackets and fittings, but it definitely must be taken into account when designing large transparent enclosures, such as turrets, bomber noses, and pilots' enclosures. It is also more important when dealing with the thermoplastic materials than with the thermosetting ones, since the thermoplastics have a greater differential coefficient of expansion.

Moisture Absorption

The thermosettings, the thermoplastics, and wood veneer materia s all absorb moisture, but to varying degrees. The thermosetting and thermoplastic materials are only slightly sensitive to moisture, and this factor may be ignored except in severe electrical applications or where dimensional tolerances are exceptionally close. Such is not the case when using the unimpregnated wood veneer materials, whose strength and dimensions vary noticeably with the moisture content. The effect of moisture on the unimpregnated wood veneer materials may be greatly reduced by the proper application of the high-grade synthetic resin finishes which have been developed over the last three or four years, but it should be borne in mind that no finish is entirely impervious to moisture, and therefore that even the best finishes merely reduce the rate of moisture absorption. Although these modern finishes offer adequate protection under fluctuating atmospheric conditions, they do not offer moisture protection when the atmospheric conditions main ain over long periods of time. For instance, if the finish was applied to the wood veneer piece in the northern part of the country under atmospheric conditions that would produce stabilisation at 8 per cent. moisture content, and the piece was then shipped to the Tropics, where the average atmospheric conditions tended to produce 15 per cent. moisture content, it could be expected that the part would eventually stabilise at 15 per cent. moisture content, although it might take six months to a year before this value was attained. If, however, the aeroplane on which this piece was mounted was moved to various parts of the country at frequent intervals, the moisture content of the piece would not materially alter, since the low rate of permeability of the modern synthetic resin finishes would protect against rapid fluctuations in humidity.

Although little research has been done to date on the moisture-absorption characteristics of the impregnated wood veneer materials, it is reasonable to expect that their sensitivity will be of the same order of magnitude as the thermosetting phenolic materials, since the impregnation protects the wood fibres to the same degree as the cotton fibres are protected in fabric base phenol fibre.

Relative Cost

The foregoing factors all pertain to the functional aspects of the application, but the analysis would not be complete unless the economic aspect were also considered. The thermosetting and thermoplastic materials are either moulded in steel dies under relatively high pressure or manufactured as sheet, tube, and bar stock that is fabricated by shearing, punching, and machining. At first glance it would seem that the attendant die expense would eliminate moulded plastics from consideration in the present aircraft quantity brackets, but such is not the case, because the metal parts against which they are competing are not manufactured by high-production processes, and also because in many cases one plastic part replaces an assembly consisting of several metal parts. Experience has indicated that moulded plastics usually can compete with strong aluminium alloy castings on a cost basis if the quantities involved are above 1000, and that where the moulded plastic part replaces a complex assembly consisting of several metal parts, the cost will be in favour of the plastic on quantities of 300 or more. These figures are, of course, approximate, but serve to indicate the limits of the quantity brackets in which cost equality occurs.

The principal reason why moulded plastics compete in aircraft in such low qu ntity brackets is that the moulded plastic part comes out of the mould in its finished form, while the metal counterpart generally requires additional operations. The cost of fixtures and labour for performing these additional operations on the metal offse s the cost of the die for manufacturing the plastic part. The material costs are usually about the same, any small difference being in favour of the plastics. It follows that where the metal counterpart would be relat vely simple to manufacture, the quantities must be large before moulded plastics become economical, and that where the metal counterpart is relatively complex moulded plastics may be economically used in quantities of only a few hundred. In quantities smaller than those discussed, moulded plastics will be the more expensive, and should not be used except in applications requiring specific properties, such as electrical insulating value, heat insulating value, or transparency.

Although moulded plastic parts are uneconomical in quantities lower than 300 to 1000, the same is not true of items such as transparent enclosures, which are made from thermoplastic sheet stock formed to shape, since the cost of the fixtures for forming the plastic sheet is relatively small. Frequently, by designing the transparent plastic parts to be self-supporting, it is possible to eliminate a great deal of the metal framing used in transparent closure designs, and the savings made by this elimination more than offset the cost of the forming fixtures for the plastics, even when small quantities are involved.

With reference to the wood veneer materials, the unimpregnated type is competitive with metal even in small quantities, since the cost of fixtures and tools for manufacturing formed plywood shapes compares favourably with the cost of metal fixtures and tools in like quantity lots. The wood veneer materials of the unimpregnated type may therefore be used in any quantity bra ket that would be contemplated for metal construction. There are not sufficient data available to draw any conclusions regarding the economic quantity brackets pertaining to the impregnated wood veneer materials, but it is reasonable to assume that the quantities will fall approximately midway between economic quantities for moulded plastics and those for unimpregnated wood veneer materials.

(To be continued)

EAST AFRICA BUYS STEEL COACHES.—The American Car and Foundry Company, at Berwick, Pa., has recently completed three mixed coaches of 3ft. 6in. gauge and four third-class coaches of 29½in. gauge for the Mozambique Railway, Portuguese East Africa. The mixed coaches are equipped to carry twelve first-class passengers, thirty-two second-class, and eighty third-class, a total of 124 passengers each. The third-class coaches are shorter and narrower, but accommodate a total of eighty passengers. In order to save weight these cars have been constructed of low-alloy high-tensile steels throughout for the framing and strength members.

Markets, Notes and News

The prices quoted herein relate to bulk quantities. Unless otherwise specified home trade quotations are delivered f.o.t. Export quotations are f.o.b. steamer

Iron and Steel in the United States

Difficulties were only to be expected in putting into operation the huge American programme of iron and steel production, but these have been largely overcome as they arose. Revised figures of the pig iron capacity of the United States at the end of the first six months of this year showed an estimated increase of 422,500 tons, bringing the total annual blast-furnace capacity of the country to 60,816,480 tons. Only two blast-furnaces were idle in the Pittsburgh district at the end of July, and several in that district have been rebuilt and enlarged. The great majority of the American blast-furnaces are now concentrating on the production of steel-making pig irons. There has also been an increase in the steel-making capacity of the United States of 628,350 tons per annum. The annual capacity of the country is now estimated at 89,198,320 tons, or 8,000,000 tons more than at the outbreak of the war. The most important increase is in the production of open-hearth steel of 139,170 tons to a total annual capacity of 78,257,200 tons. The United States is expected to produce steel during the last half of the year at a rate of 1,710,674 tons weekly. A certain amount of congestion has developed in the semi-finished steel section of the industry. Most of the orders for this class of material are urgent, and 90 per cent. are for immediate delivery under the priority scheme. Sheet mills producing special qualities have reported to the authorities that their operations have been limited to 60 to 75 per cent. of capacity owing to the difficulty of obtaining supplies of semi-finished steel. A proposal is now under consideration for appointing one individual to deal with this and similar problems in the steel trade. An intense national drive to collect scrap is now in progress in the United States, but criticisms have been heard that it has failed to obtain the necessary quantities. Automobile "graveyards" yielded 434,500 tons in July. This is a considerable improvement upon the quantities of this class of scrap obtained in 1941 before the drive was undertaken, when only 150,000 tons were collected. In June the consumption of iron and steel scrap by the American steel industry was 4,608,000 tons, and it was estimated that 57,000,000 tons will be required for the year 1942, 10,000,000 more tons than was received in 1941. A proposal to ship scrap to the United States from Great Britain by using empty cargo space has been condemned as impracticable. It is stated that supplies to re-rolling mills have been reduced as a result of extensive shipments of Lease-Lend semi-finished steel, but it is realised that these are necessary. In July shipbuilding absorbed a large proportion of the 1,150,000 tons of plates produced in that month.

The Pig Iron Market

Satisfactory conditions rule in the pig iron market in most districts. The demand is heavy and in the case of the higher class of pig irons has led to some stringency, but the Control, by careful supervision of distribution, has managed to keep the firms engaged upon war work fully supplied. Nevertheless, substitutes for the iron normally used have had to be taken to an increasing extent. Consumers, however, are becoming used to this, and there is a considerable amount of speculation as to whether certain irons will be wanted so much after the war as formerly, now that consumers have learned that substitutes can be used with satisfactory results. There are liberal supplies of high-phosphoric pig iron available, but the light castings foundries, the principal peacetime users of this description of pig iron, are only poorly employed, and the demand is comparatively small. Lately, however, under the persuasion of the Control, it has been used in many cases for which it would have been considered unsuitable in pre-war days. The demand for this class of pig iron as a substitute for higher quality is not sufficient to make up for the light demand which has existed for some time, and which has resulted in substantial accumulations at the foundries. Supplies for most districts under wartime conditions are drawn from the English Midlands. Most of the furnaces on the North-East Coast are employed in producing basic, hematite, refined irons, and ferro-manganese, and little foundry iron is manufactured. As a result, the founders in that district are receiving considerable supplies from the Midlands. There is a big production of basic pig iron in the country, but so heavy is the demand from the steel works that it is barely sufficient to meet requirements. The demand from the heavy engineering industries for engineering castings has resulted in important tonnages of refined pig iron and low and medium-phosphoric pig irons being taken up, and this has created some tightness in the supply position. The Control exercises great care in issuing licences, and more of these irons would be consumed were they more easily obtainable. A moderate demand exists for forge irons, which the producing works are well able to cope with.

The North-East Coast and Yorkshire

Activity at the steel works on the North-East Coast is increasing, and few of the producers are in a position to accept orders for the current period. In fact, at most works there is a rush to complete contracts before October 1st, when the next period commences. Some fourth-quarter bookings have already been placed, and every branch of the steel industry is fully occupied. The demand for plates is still pressing hardly upon the manufacturers, and no relief from the pressure of demand is likely for a long time. The shipyards are taking large tonnages, and there is also an insistent call for plates from the wagon, tank, and boiler-makers. The armament and aircraft manufacturers are calling for large quantities of alloy and special steels, and the production of these descriptions has to be maintained at a high rate to satisfy their requirements. Recently, a sharp improvement took place in the demand for heavy structural steel, and the flow of orders for this class of material has increased since the improvement first set in. The improvement is generally attributed to the considerable quantities which are being taken up for the expansion of works, military buildings, &c. The re-rolling industry is actively employed upon the production of light structural steel and small bars. Within the last month or two the raw materials position has somewhat improved, and the re-rolling mills find no difficulty in obtaining their full supplies of semis. The home production of billets and sheet bars is at a high level and is supplemented by imports. The Yorkshire steel industry is employed practically at capacity, and in certain directions activity is increasing. The works are assured of full-time working until the end of the quarter, and in many cases it is probable that they will carry over substantial contracts into the new period. There is an insatiable demand for basic steel, and production is being increased by bringing more furnaces into operation. The finished steel branches of the industry are operating at capacity, and in some cases there is a tendency for delivery dates to lengthen. The shipyards and the ship-repairing yards are increasing their demands upon the industry and are taking up large tonnages of plates.

Scotland and the North

The steel works in Scotland are working under heavy pressure from consumers of all descriptions of finished steel. The chief demand is for plates from the shipbuilding industry, and some of the works have fallen into arrears in deliveries. The works, however, are operating under conditions of great activity in an endeavour to reduce, as far as possible, these arrears before the end of the third delivery period. Bookings for plates have been made for delivery for several months ahead, and there is no doubt that substantial tonnages will be carried over into the next period. The demand seems chiefly for heavy plates, but there is also a considerable business passing in medium and light descriptions. The call for alloy steels has not diminished, and the producing works are hard pressed to meet the requirements of consumers. The orders placed for this class of steel are in the high-priority category and the demand comes largely from the armaments and munition makers. It is said that the demand for alloy steels in July was particularly heavy, and was, if anything, exceeded in August. The demand for steel bars is active, and considerable tonnages are being taken up by consumers, and particularly by the engineering industry. The re-rolling works are well employed, and with good supplies of billets are able to meet consumers' requirements of small bars and small sections. Throughout Lancashire the consuming industries are fully employed, and a great part of the work in hand comes in the high-priority category. High as is the production of steel, it passes into almost immediate consumption. Engineering works are taking up comparatively large tonnages of special steels which are entirely used in the war effort and heavy tonnages of plates and sections are also passing to this industry. There is a steady call from the collieries for roofing bars, arches, &c., and in spite of the heavy demand from other industries the steel makers are maintaining satisfactory supplies. Business in sheets, although it has improved somewhat during the past week or two, is moderate. It includes a big proportion of Government orders and considerable contracts for special descriptions. All the steel mills on the North-West Coast are actively employed, and, with adequate supplies of raw material available, important outputs are being attained. Of late, there has been an increase in specifications for structural steel, but most of the works producing this class of material are in a position to accept fresh orders.

Copper, Tin, Lead, and Spelter

Although Great Britain is only a small producer of non-ferrous metals, the steps which were taken at the beginning of the war to ensure supplies of copper, lead, and spelter have been successful in maintaining supplies of metals to the war industries. The need, however, for economising in the use of all these metals has been apparent for a long time, and the Non-Ferrous Metal Control has now been instrumental in issuing a timely reminder through the British Standards Institution, which is published on page 235 of this issue. There is no doubt that, compared with Great Britain and the United States, the Axis Powers are in a much less favourable position with regard to supplies of non-ferrous metals, and have to resort to a much greater degree to substitutes and *ersatz* materials. The copper position in Great Britain is satisfactory to the extent that firms engaged on war work get their full supplies, but they have to economise in their use, and there has been something approaching a revolution in the practice of the consuming industries designed to conserve available stocks. When the war industries have received their allocation there is no margin for purposes unconnected with the war. In the United States, as a result of the drastic supervision of the use of copper, the position so far as the war industries are concerned is reported to be easier, although the authorities still regard the position as being somewhat delicate, but this is not surprising in view of the enormous consumption for American war production. The tin position has been difficult since the Japanese overran the principal Eastern sources of supply. Every country producing the metal which is controlled by the United Nations is being pressed to increased production. Since the outbreak of the war, efforts have been made to increase the Canadian production. Canada's output at present is about 500 tons of metallic tin, or 15 per cent. of her present requirements, according to *Tin*, the official publication of the Tin Producers' Association. An increased tonnage of ore, if it is possible to produce it, could be handled by the smelting capacity in the country. It is announced in the United States that the Texas tin smelter capacity is to be increased from 50,000 to 74,000 tons per annum. The lead position is not unsatisfactory in Great Britain, but the Non-Ferrous Metal Control, by carefully supervising applications for licences, is restricting its consumption to national needs. The spelter position is somewhat stringent, and great care is being exercised by the Control in releasing the metal. In the United States the position appears to have greatly improved during the last twelve months, but some authorities in that country are apparently still nervous regarding the future, and estimate that there is still a probable deficiency. So far as can be judged, however, the American war industries are receiving all the metal necessary.

SWEDISH ALL-WELDED TANK WAGON.—According to a paragraph in the Stockholm papers, a Swedish shop is building a type of tank wagon with several novel features. The chief advantages seem to be that, owing to considerably reduced weight, the volume of the container can be greatly increased. The largest tank wagons at present used by Swedish railways have a tank volume of 4500 gallons, the wagon itself weighing 13 tons. The largest wagons of the new type weigh only 11 tons, but carry 6200 gallons of oil or other liquid. The reduction in weight is effected by having no special truck, the tank itself being welded throughout and made and braced so strongly that it will carry the load and withstand all draw-bar and buffer stresses. The transverse bearing bars or bolsters are welded direct on the tank, and at each end welded to the buffer plates. The spring suspension is combined with the bearing bars, these being welded on in such a way that it has been possible to simplify the draw gear devices. The two pony trucks of this simple description are united with each other by longitudinal angle bars, which are braced across by stay bars and in height by a supporting framework. On account of the welding and simplification of the support gear which replaces a regular truck the strength is increased at the same time as the weight is lowered. Roller bearings of the type adopted by the Swedish State Railways are fitted.

Notes and Memoranda

Rail and Road

ALEXANDRA PALACE LINE, L.N.E.R.—In order to conserve fuel and motive power, the L.N.E.R. now operates passenger services between Finsbury Park and Alexandra Palace only during business hours.

L.M.S. SALVAGE.—In the last twelve months 350,000 metal bands, weighing 38 tons, have been collected by the L.M.S. railway staff at Fleetwood from dilapidated and broken fish boxes. In the same period 13 tons of old trawl netting have been recovered from the sea. Among strange items salvaged for war purposes by L.M.S. staffs at other places on the system are horsehair, granite dust, wool pickings, abandoned boots and shoes, and 2 tons of discarded torch batteries.

END OF A VETERAN LOCOMOTIVE.—Famed in the 1860s as one of Britain's fastest passenger engines, the 75-year-old L.M.S. locomotive "No. 20,008" has made its last journey—to the works for breaking up. It had a busy life. Until quite recently it continued to operate in fast passenger service as a pilot engine. Later it worked the engineer's inspection saloon in the Crewe district, and finally ended its career on shunting operations at Watford. Its total mileage reached the high figure of 1,613,019.

CEMENT IN LIEU OF COAL TAR.—The Spanish railways use more than three-quarters of a million tons of coal briquettes a year and are now faced with the problem of how to make them. Most of the coal used comes from the mines of Asturias, which is friable, and because it contains a large proportion of smalls and slack recourse is had to briquetting. Recently, however, the lack of imported coal tar products has made it necessary to experiment with other binding mediums, and so far cement seems to hold the field.

A LONG CONCRETE VIADUCT.—The Missour Pacific Brownsville to New Orleans Railway has almost completed an extensive viaduct which was rendered necessary by the Mississippi River flood control plan. This work entailed the diversion of the New Orleans line on to a high-level track which is being carried for 3¼ miles in the vicinity of Morganza on a continuous concrete viaduct. The work has meant the driving of 736,000 cubic feet of foundation piles and the use of 50,400 cubic yards of concrete and 5125 tons of reinforcing steel.

LOCOMOTIVE BUILDING IN U.S.A.—Departmental statistics published in June show that the May shipments of railway locomotives amounted to 111, as compared with 132 in April and 87 in May, 1941. Shipments for the first five months of the year stand at 557 locomotives, including 216 steam, 6 electrics, 312 diesel-electrics, and 23 of other types, as compared with a January-May, 1941, total of 351, including 78 steam, 10 electrics, 243 diesel-electrics, and 20 of other types. Unfilled orders at the end of May totalled 1586 locomotives of all kinds.

Air and Water

A NEW ZEALAND MINESWEEPER.—The launch has recently taken place of the first steel minesweeper to be built at Port Chalmers, New Zealand.

THE LIFEBOAT SERVICE.—In three years of war lifeboats of the Royal National Lifeboat Institution have rescued 4775 lives. They have rescued more lives in these three years of war than in the last thirteen years of peace. In the four years of the last war they rescued nineteen lives every week. In the twenty years of peace between the two wars they rescued seven lives a week. In these three years they have rescued thirty lives a week. Since the beginning of this war lifeboatmen have won from the Institution 157 medals for gallantry. They have also won four British Empire Medals, two Distinguished Service Medals, and one George Medal. Six lifeboatmen have lost their lives on service.

INSTITUTE OF MARINE ENGINEERS.—The next examinations for admission to the Institute of Marine Engineers will be held as follows:—Students (common preliminary examination), April 6th to 9th and October 5th to 8th, 1943; graduates (Section A of associate membership examination), May 31st, June 2nd and 4th, 1943; associate members, May 31st to June 7th, 1943. Syllabuses of these examinations, copies of previous papers, and particulars of exempting qualifications will be supplied on application to the secretary at 73, Amersham Road, High Wycombe, Bucks. An examination for the award of a Lloyd's Register Scholarship in Marine Engineering, value £100 a year for three years, tenable at a British university, will be held on May 31st to June 4th, 1943. Candidates must be British subjects between the ages of 18 and 21, who have been employed in engineering, either as apprentices or as college students, with the intention of entering upon the profession of marine engineering, and have served at least two years in commercial engineering workshops. Apprentices in H.M. dockyards are not eligible for the scholarship. Full particulars may be obtained from the secretary of the Institute of Marine Engineers.

CONCRETE CHUTE FOR TIMBER FLOATING.—Most of the timber cut in the Swedish forests is floated down to the sawmills in the rivers. As the flow in most of them is frequently interrupted by falls, rapids, and shallow reaches, it is customary to shunt the timber past such places in flumes, mostly timbered structures. In later years concrete flumes have been substituted here and there. They are, like the wooden flumes, a rather wide V shape, which for one thing saves water, and also makes the logs slide better along the slanting sides. In the Dalälven River in Central Sweden, which carries an immense quantity of timber to large sawmills and pulp mills on both sides of the mouth, it has been necessary to construct long flumes past the falls near its outflow. One of these timber floating channels, built as a concrete structure, was recently opened for service. It is over 10 miles in length and in parts it is cut down through gravel ridges and in one place passes across a stream as an aqueduct. The flume is V-shaped, as usual, and for the most part supported on the lower "point" of the angle, which is flattened out to a width ranging from 4in. to 4ft., the top width varying from 6ft. to 12ft. These variations in section are made to compensate for the difference in fall and as much as possible obtain a uniform rate of flow.

Miscellanea

WAGES CLAIM.—The Engineering and Allied Employers' National Federation has received from the unions in the engineering industry an application for a wage increase. The claim is for an all-round increase of 11s. a week, a 33½ per cent. increase of the base rates to all plain-time workers, and the restoration of overtime and other conditions which were in force before June, 1931.

NEW PETROLEUM ORDER.—The Minister of Fuel and Power has made the Petroleum (No. 2) Order, 1942, which came into force on September 1st, 1942. This Order provides that, except for medicinal purposes or under the authority of a licence, liquid paraffin shall not be treated or used or blended with any other petroleum product or any other substance. Forms of application for licences can be obtained from the Petroleum Division, Ministry of Fuel and Power, 7, Millbank, London, S.W.1. The Order supersedes the Petroleum Order, 1942, but continues the provisions of that Order relating to the acquisition and supply of petroleum products.

MINISTRY OF HOME SECURITY INDUSTRIAL BULLETIN NO. 2.—Industrial Bulletin No. 2, prepared by the Ministry of Home Security, has been published by the Stationery Office. These Bulletins, which contain information obtained under raid conditions, are intended to assist industry and commerce to keep their air raid precautions schemes up to date in civil defence technique. They are for sale on a restricted basis. Copies can be obtained, price 9d. each, on written application to H.M. Stationery Office, York House, Kingsway, London, W.C., by clerks to local authorities or county councils, or the principals of public utility companies or industrial or commercial concerns or of institutions, or by county secretaries of the St. John Ambulance Brigade, the British Red Cross Society, and St. Andrew's Ambulance Association.

CONTROL OF RUBBER.—Two further Orders restricting the consumption of rubber have been made by the Minister of Supply, and came into force on September 17th. The Control of Rubber (No. 16) Order, which deals with belting, imposes further limitations on the quantity of crude rubber or balata which may be used in the production of conveyor, elevator, or transmission belting, and also prohibits the manufacture of certain types of belting, and of belting not required for essential purposes. The restrictions upon the acquisition or disposal of belting which were imposed by the Control of Rubber (No. 8) Order are continued. The Control of Rubber (No. 17) Order deals with the manufacture of rubber hose. Only hose of the descriptions scheduled in the Order may be manufactured, and for hose of these descriptions limits are prescribed to the thickness of the rubber and the volume of new rubber that may be used. The size of the internal diameter of the hose and the number of plies the hose may contain are also limited. Other provisions restrict the use of coloured rubber to certain essential purposes, and prohibit the manufacture of all-rubber hose. There are exemptions for hose to be used in connection with aircraft and armoured fighting vehicles. Copies of the Orders may be obtained from H.M. Stationery Office.

Personal and Business

MR. ALAN GREIG has been appointed secretary of the Blyth Dry Docks and Shipbuilding Company, Ltd.

MR. W. P. DOBSON, chief testing engineer of the Canadian Hydro-Electric Power Commission, has been elected President of the Dominion Council of Professional Engineers.

E. H. JONES (MACHINE TOOLS), Ltd., inform us that their new Leeds branch will open at 59A, Albion Street, Leeds, on October 1st, under the management of Mr. Harry Cottam.

MR. T. NIGHTINGALE has been appointed chairman of Sheffield Steel Products, Ltd. Captain W. M. Hungerford Pollen has been elected deputy chairman, and Mr. J. T. Henry becomes managing director.

THE IRON AND STEEL CONTROL has announced that at a meeting of members of the British Iron and Steel Federation held in London on September 15th it was reported that Mr. I. F. L. Elliot, who had been Commercial Director of the Federation and Managing Director of the British Iron and Steel Corporation since November, 1935, had ceased to hold these offices.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

Institute of Physics

Tuesday, Sept. 22nd.—Royal Institution, 21, Albemarle Street, W.1. Discussion, "The Determination of Equilibrium Diagrams by X-Ray Methods." 11 a.m.

Institution of Electrical Engineers

Saturday, Sept. 26th.—N.E. STUDENTS' SECTION: Visit to A. Reyrolle and Co., Ltd.

Thursday, Oct. 1st.—Savoy Place, Victoria Embankment, W.C.2. Presidential Address, Professor C. L. Fortescue. 5.30 p.m.

Wednesday, Oct. 7th.—WIRELESS SECTION: Savoy Place, Victoria Embankment, W.C.2. Chairman's Address, R. L. Smith-Rose. 5.30 p.m.

Wednesday, Oct. 14th.—TRANSMISSION SECTION: Savoy Place, Victoria Embankment, W.C.2. Chairman's Address, P. E. Rycroft. 5.30 p.m.

Thursday, Oct. 15th.—INSTALLATIONS SECTION: Savoy Place, Victoria Embankment, W.C.2. Chairman's Address, R. Grierson. 5.30 p.m.

Institution of Engineers and Shipbuilders in Scotland

Tuesday, Oct. 20th.—39, Elmbank Crescent, Glasgow Presidential Address, F. C. Stewart. 6.30 p.m.

Institution of Mechanical Engineers

Saturday, Sept. 19th.—YORKS BRANCH: Queen's Hotel, Leeds. "The Application of Statistical Control to the Quality of Materials and Manufactured Products," Sir F. Gill. 3 p.m.

Monday, Oct. 5th.—SCOTTISH BRANCH: Royal Technical College, Glasgow. "Poison Gases," Professor W. M. Cumming; and "Physiological Effects and Treatment," Dr. A. Goodall. 7.30 p.m.

Friday, Oct. 9th.—Storey's Gate, Westminster, S.W.1. "The Training Activities of the Ministry of Labour," E. Watson Smyth. (Informal meeting.) 5.30 p.m.

Friday, Oct. 9th.—SCOTTISH GRADUATES' SECTION: Royal Technical College, Glasgow. "Wartime Effects on Engineer and Patent Law," R. W. Cunningham. 7.30 p.m.

Thursday, Oct. 15th.—MIDLAND BRANCH: James Watt Memorial Institute, Birmingham. "Fencing of Machinery," H. A. Hepburn. 5.30 p.m.

Junior Institution of Engineers

To-day, Sept. 18th.—39, Victoria Street, S.W.1. "Railcars," N. L. Ablett. 6 p.m.

Friday, Sept. 25th.—39, Victoria Street, S.W.1. "My Place in the Institution," R. Lowe. 6 p.m.

Friday, Oct. 9th.—39, Victoria Street, S.W.1. "Sinking and Erection of Cast Iron Tubbings," H. A. Hatt. 6 p.m.

Manchester Association of Engineers

Saturday, Sept. 26th.—Engineers' Club, Albert Square, Manchester. Presidential Address, H. L. Butterworth. 2.30 p.m.

Saturday, Oct. 10th.—Engineers' Club, Albert Square, Manchester. "Plastics and their Application to Engineering," J. Prior. 2.30 p.m.